PATENT ABSTRACTS OF JAPAN

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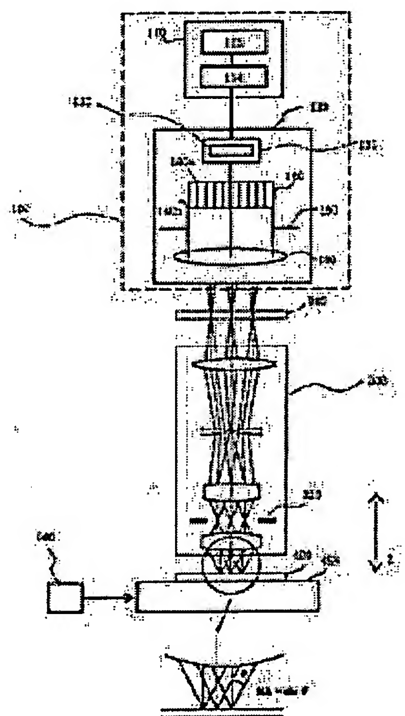
(54) EXPOSING METHOD AND EQUIPMENT THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an exposing method and equipment which can expose a mask pattern having fine (e.g. at most 0.15 μm) line width, with high resolution without changing a mask, in which mask pattern various kinds of patterns, L and S patterns, isolated and complicated patterns exist mixedly.
SOLUTION: A phase shift mask has a desired pattern and a dummy pattern which is overlapped with the desired pattern and has periodicity. Out of the desired pattern, a part which is to be resolved by the effect of the dummy pattern is made wider than the line width of the dummy pattern, thus forming the phase shift mask. By using an illumination light which has a peak of intensity distribution in the vicinity of an optical axis, the phase shift mask is illuminated. A light which passed the phase shift mask is projected on a surface to be exposed via a projection optical system. As a result, the desired pattern is transferred on the surface to be exposed.



CLAIMS

[Claim(s)]
[Claim 1]A phase shift mask which has a desired pattern and a pattern of a dummy with periodicity put on the pattern concerned, It forms by making thicker than line width of a pattern of said dummy a portion which should be made to resolve by an effect of a pattern of said dummy among patterns of said request, An exposure method transferring a pattern of said request to said exposed side by illuminating said phase shift mask using illumination light which has a peak of intensity distribution near the optic axis, and projecting light which passed through said phase shift mask on an exposed side via a projection optical system.
[Claim 2]An exposure method performing multiplex Lighting Sub-Division in an exposure method which exposes a pattern on a mask on an exposed side with a projection lens with an effective light source which is equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division as illumination light using a phase shift mask which piled up a detailed period pattern a pattern space and near desired.
[Claim 3]The 1st pattern part that aligns an interval predetermined [pattern / of said request] in 1st at least two line, A step which has the 2nd pattern part that has the 2nd line with bigger line width than the 1st line, and forms said phase shift mask, The exposure method according to claim 1 piling up said 1st line of said 1st pattern part with a dark line part of a pattern of said dummy, and putting said 2nd line of said 2nd pattern part on a pattern of said dummy.
[Claim 4]The exposure method according to claim 1 which has the 2nd pattern part characterized by comprising the following, and said some of patterns of said request are said 1st line of said 1st pattern part, and is characterized by making line width of the 1st line concerned larger than line width of a dark line part of a pattern of said dummy.
The 1st pattern part that aligns an interval predetermined [pattern / of said request] in 1st at least two line.
The 2nd line with bigger line width than the 1st line.

[Claim 5]The exposure method according to claim 1, wherein a step which forms said phase shift mask provides a shade part in a pattern of said request and does not provide a shade part in a pattern of said dummy.
[Claim 6]The exposure method according to claim 1, wherein a step which forms said phase shift mask constitutes a pattern of said request as a shade part and a light transmission section of half-tone phase shift type.
[Claim 7]The exposure method according to claim 1, wherein illumination light which has a peak of intensity distribution near [said] the optic axis has a circular effective light source configuration.
[Claim 8]The exposure method according to claim 2, wherein said small sigma Lighting Sub-Division has a circular effective light source configuration.
[Claim 9]The exposure method according to claim 1 with which illumination light for which it has a peak of intensity distribution near [said] the optic axis is characterized by sigma being 0.3 or less.
[Claim 10]The exposure method according to claim 2 with which said small sigma Lighting Sub-Division is characterized by sigma being 0.3 or less.
[Claim 11]The exposure method according to claim 2, wherein said large sigma Lighting Sub-Division has an effective light source configuration of a quadrupole.
[Claim 12]The exposure method according to claim 2 with which said large sigma Lighting Sub-Division is characterized by sigma being 0.6 or more.
[Claim 13]The exposure method according to claim 2, wherein sigma has a bigger effective light source configuration than 1 in said large sigma Lighting Sub-Division.
[Claim 14]The exposure method according to claim 11, wherein each illumination light of said quadrupole has equal sigma.
[Claim 15]The exposure method according to claim 2, wherein said large sigma Lighting Sub-Division has an effective light source configuration of zona orbicularis.
[Claim 16]An exposure device having the exposure mode which can perform an exposure method given in any 1 clause among Claims 1-15.
[Claim 17]In an exposure device which consists of an illumination system which illuminates a pattern on a mask and this mask, and a projection optical system projected on an exposed side, An exposure device this mask's consisting of a phase shift mask which piled up a detailed period pattern a pattern space and near desired, and an illumination system's having a multiplex effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division, and having the multiplex illumination system with which these smallness sigma Lighting Sub-Division and large sigma Lighting Sub-Division were combined.
[Claim 18]The exposure device according to claim 17 including a diaphragm which has an opening of a fivefold pole so that said multiplex effective light source configuration may become a fivefold pole.
[Claim 19]The exposure device according to claim 17, wherein sigma has a bigger effective light source configuration than 1 in said large sigma Lighting Sub-Division.
[Claim 20]The exposure device according to claim 17 which said large sigma Lighting Sub-Division has an effective light source configuration of a quadrupole, and is characterized by sigma of each illumination light of said quadrupole being equal.
[Claim 21]The exposure device according to claim 17, wherein said large sigma Lighting Sub-Division forms an effective light source

configuration of zona orbicularis and said small sigma Lighting Sub-Division forms a circular effective light source configuration provided inside said zona orbicularis.
[Claim 22]The exposure device according to claim 17, wherein said lighting system has equipment which has the function to adjust a position of a peak of a function to adjust each light exposure of said small sigma Lighting Sub-Division and said large sigma Lighting Sub-Division, and/or said large sigma Lighting Sub-Division.
[Claim 23]A device manufacturing method comprising:
A step which carries out projection exposure of the processed object using an exposure device given in any 1 clause in given in Claims 16-22.
A step which carries out a predetermined process to said said processed object by which projection exposure was carried out.

[Claim 24]A device manufactured from said processed object by which projection exposure was carried out using an exposure device given in any 1 clause in given in Claims 16-22.
[Claim 25]A phase shift mask, wherein a portion which has a desired pattern and a pattern of a dummy with periodicity put on the pattern concerned, and should be resolved by an effect of a pattern of said dummy among patterns of said request is made thicker than line width of a pattern of said dummy.
[Claim 26]A pattern of said request has the 1st pattern part where 1st at least two line aligns at the predetermined intervals, and the 2nd pattern part that has the 2nd line with bigger line width than the 1st line, and said some of patterns of said request are said 1st line of said 1st pattern part.
The mask according to claim 25, wherein line width of the 1st line concerned is larger than line width of a dark line part of a pattern of said dummy.

[Claim 27]The mask according to claim 25 providing a shade part in a pattern of said request, and not providing a shade part in a pattern of said dummy.
[Claim 28]The mask according to claim 25, wherein a pattern of said request of said phase shift mask comprises a shade part and a light transmission section of half-tone phase shift type.
[Claim 29]A manufacturing method of said mask which manufactures said mask as a phase shift mask by forming a desired pattern in a mask, piling up a pattern of a dummy which has periodicity in the pattern concerned, and making some patterns of said request thicker than a pattern of said dummy.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]Generally especially this invention about exposure Semiconductor chips, such as IC and LSI, It is related with the exposure device used for manufacture of the wide area pattern used by various devices called image sensors, such as sensing elements, such as display devices, such as a liquid crystal panel, and a magnetic head, and CCD, and micro mechanics and a method, a device manufacturing method, and the device manufactured from said processed object. Here, micro mechanics applies the Integrated Circuit Sub-Division production technology to manufacture of a fine structure body, and says the technology which makes a mechanical system with an advanced function of the micron unit.
[0002]
[Description of the Prior Art]A photolithography process is a process of transferring a mask pattern using an exposure device to the photosensitive substance (resist) applied to a silicon wafer, a glass plate (only henceforth a "wafer"), etc.
The process of a resist application, exposure, development, etching, and resist removal is included.
Among these, in exposure, resolution, superposition accuracy, and three parameters of a throughput are important. The accuracy at the time of the lower limit and superposition accuracy which can transfer resolution correctly piling up some patterns on a wafer, and a throughput are number of sheets processed per unit time.
[0003]When manufacturing a device using photolithography technique, the projection aligner which projects on a wafer the pattern drawn by the mask or the reticle (these terms are used exchangeable with this application) according to a projection optical system, and transfers a pattern is used from the former. a projection optical system -- the diffracted light from a pattern -- a wafer top -- interference -- and image formation is carried out and zero-order [from a pattern] and the primary [**] diffracted light (namely, 3 light flux) are made to interfere in the ordinary exposure
[0004]The periodic line and space (L&S) pattern in which the mask pattern approached, Although contiguity and a periodic contact whole pattern, and the isolated pattern isolated without approaching are included, in order to transfer a pattern with high resolution, it is necessary to choose the optimal exposing conditions (Lighting Sub-Division conditions, a light exposure, etc.) according to the kind of pattern.
[0005]The resolution R of a projection aligner is given by the following Rayleigh's formula using the wavelength lambda of a light source, and the numerical aperture (NA) of a projection optical system.
[0006]
[Mathematical formula 1]

$$R=k_1\ (\lambda/NA)$$

[0007]k_1 is a constant which becomes settled by a development process etc. here, and, in exposure, k_1 is about 0.5-0.7 usually.
[0008]Corresponding to high integration of a device in recent years, the miniaturization of the pattern transferred, i.e., high-resolution-izing, is demanded increasingly. In order to acquire high resolving power, it is effective to enlarge the numerical aperture NA from an upper type and to make wavelength lambda small, but these improvements have reached the limit at the present stage, and it is difficult to usually form a pattern of 0.15 micrometer or less at a wafer in exposure. Then, interference and the phase shift mask technology which carries out image formation are proposed from the former in 2 light flux in the diffracted light which passed through the pattern. By reversing 180 degrees of phases of the light transmission portion which a mask adjoins, a phase shift mask offsets the zero-order diffracted light, the two primary [**] diffracted lights are made to interfere in it, and image formation is carried out. according to this technology, k_1 of an upper type is substantially set to 0.25 -- since it can do, the resolution R can be improved and a pattern of 0.15 micrometer or less can be formed in a wafer.
[0009]
[Problem to be solved by the invention]However, although the conventional phase shift mask technology was effective for a simple pattern like a periodic L&S pattern, it was difficult to expose an isolated pattern and arbitrary complicated patterns with sufficient exposure performance (namely, resolution, superposition accuracy, and a throughput). Production needs to be shifting to the high-value added system chip in which a variety of patterns are intermingled, and especially the semiconductor industry in recent years needs to make two or more kinds of patterns intermingled also on a mask.
[0010]On the other hand, as it is in the open patent Heisei 11(1999) No. 143085 gazette, it is possible to use the double exposure (or multiple exposure) which exposes the pattern of a different kind using two masks independently, but. Since the conventional double exposure needs two masks, a cost hike is caused, a throughput falls for two exposure and the high superposition accuracy of two exposure is needed, there are many problems which should be solved practically.
[0011]Then, it has detailed line width (for example, 0.15 micrometer or less), and sets it as the illustration purpose of this invention to provide the exposure method and equipment with sufficient resolution which can be exposed, without exchanging masks for the mask pattern in which even various patterns or from a L&S pattern to isolation and a complicated pattern are intermingled.

[0012]
[Means for solving problem]To achieve the above objects, the exposure method as a one side face of this invention, The phase shift mask which has a desired pattern and a pattern of a dummy with the periodicity put on the pattern concerned, It forms by making thicker than the line width of said dummy pattern the portion which should be made to resolve by the effect of said dummy pattern among the patterns of said request, The pattern of said request is transferred to said exposed side by illuminating said phase shift mask by the illumination light which has a peak of intensity distribution near the optic axis, and projecting the light which passed through said phase shift mask on an exposed side via a projection optical system.
[0013]An exposure method as another side of this invention, In an exposure method which exposes a pattern on a mask on an exposed side with a projection lens, an effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division performs multiplex Lighting Sub-Division as illumination light using a phase shift mask which piled up a detailed period pattern a pattern space and near desired.
[0014]An effective light source configuration is circular, sigma is 0.3 or less, and illumination light (or small sigma Lighting Sub-Division) which has a peak of intensity distribution near the optic axis brings about interference of the zero-order diffracted light and the primary [**] diffracted light, for example. The former exposure method demonstrates the effect in this way only by illumination light which has a peak of intensity distribution near the optic axis.
[0015]Large sigma Lighting Sub-Division brings about interference of 2 light flux which sigma is 0.6 or more in zona orbicularis or a quadrupole, and an effective light source configuration becomes from the zero-order diffracted light and the primary [+] primary [-] diffracted light, for example. A diaphragm which has said (arranged at a pupil surface of a projection optical system and a conjugate position) effective light source configuration as an opening can attain these Lighting Sub-Division.
[0016]An above-mentioned exposure method establishes a difference of a dummy pattern and a light exposure by fattening some patterns of (1) request, (2) Expose a pattern which has said periodicity by illumination light of a portion of a peak near the optic axis, (3) Expose a pattern of said request by illumination light of a portion of the outside of a portion of said peak, and form a desired pattern in an exposed side by choosing a threshold value (resist) of (4) exposed side suitably.
[0017]The 1st pattern part that aligns an interval predetermined [pattern / of said request] in 1st at least two line, It has the 2nd pattern part that has the 2nd line with bigger line width than the 1st line, said 1st line of said 1st pattern part may be piled up with a dark line part of a pattern of said dummy, and said 2nd line of said 2nd pattern part may be put on a pattern of said dummy. Resolution performance can be raised by making the 1st detailed line and its neighborhood into periodical structure. Said some of patterns of said request are said 1st line of said 1st pattern part, and it may make line width of the 1st line concerned larger than line width of a dark line part of a pattern of said dummy. A difference can be given and emphasized to a light exposure with a dummy pattern by fattening a little detailed portion of a desired pattern.
[0018]It is not necessary to provide a shade part in a pattern of said request, and to provide a shade part in a pattern of said dummy. Since it can distinguish between a desired pattern and a dummy at a light exposure of a pattern, a high pattern of contrast can be formed. A pattern of said request may be constituted as a shade part and a light transmission section of half-tone phase shift type. Also by this composition, it can distinguish between a light exposure with a dummy pattern, and a desired pattern can be emphasized.
[0019]The exposure device as a one side face of this invention has the exposure mode which performs an above-mentioned exposure method. The exposure device as another side of this invention, In the exposure device which consists of an illumination system which illuminates the pattern on a mask and this mask, and a projection optical system projected on an exposed side, This mask consists of a phase shift mask which piled up the detailed period pattern a pattern space and near desired, an illumination system has a multiplex effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division, and it has the multiplex illumination system with which these smallness sigma Lighting Sub-Division and large sigma Lighting Sub-Division were combined. These exposure devices can also do so an operation of an above-mentioned exposure method.
[0020]The device manufacturing method as another side of this invention is provided with the following.
The step which carries out projection exposure of said processed object using an above-mentioned exposure device.
The step which carries out a predetermined process to said said processed object by which projection exposure was carried out.
The effect extends to the device itself whose claims of the device manufacturing method which does so an operation of an above-mentioned exposure device and the same operation are middle and an end product thing. This device contains semiconductor chips, such as LSI and VLSI, CCD, LCD, a magnetic sensor, a thin film magnetic head, etc., for example.
[0021]The mask manufacturing method as another side of this invention, A desired pattern is formed in a mask, the pattern of the dummy which has periodicity in the pattern concerned is piled up, and said mask is manufactured as a phase shift mask by making some patterns of said request thicker than the pattern of said dummy. The mask manufactured by this method does an above-mentioned operation so.
[0022]The further purpose of this invention or the other features will be clarified by the desirable embodiment described with reference to an accompanying drawing below.
[0023]
[Mode for carrying out the invention]Hereafter, the illustration exposure device of this invention is explained with reference to an accompanying drawing. Here, drawing 1 is a schematic block diagram of the exposure device 1 of this invention. As shown in drawing 1, the exposure device 1 is provided with the following.
Lighting system 100.
Mask 200.
Projection optical system 300.
The plate 400, the stage 450, and the image formation position adjustment 500.

[0024]Although the exposure device 1 of this embodiment is a projection aligner which exposes the circuit pattern formed in the mask 200 by the step and scanning method on the plate 400, this invention can apply a step and repeat system and other exposure systems. Here, a step and scanning method scans a wafer continuously to a mask, and exposes a mask pattern to a wafer, and it is the exposing method which carries out step moving of the wafer after [of one shot] exposure completion, and moves to the exposure region of the following shot. A step and repeat system is the exposing method which carries out step moving of the wafer

for every one-shot exposure of the shot of a wafer, and moves the following shot to an exposure region.
[0025]The lighting system 100 illuminates the mask 200 in which a circuit pattern for transfer was formed, and has the light source part 110 and the illumination-light study system 120.
[0026]The light source part 110 is provided with the following.
Laser 112 as a light source.
The beam plastic surgery system 114.

[0027]Light from pulse lasers, such as an ArF excimer laser with a wavelength of about 193 nm, a KrF excimer laser with a wavelength of about 248 nm, and an F_2 excimer laser with a wavelength of about 157 nm, can be used for the laser 112. A kind of laser is not limited to an excimer laser, for example, an YAG laser may be used and the number of the laser is not limited, either. For example, if two solid-state lasers which operate independently are used, there will be no coherence between solid-state lasers, and a speckle resulting from a coherence is reduced considerably. In order to reduce a speckle furthermore, an optical system may be made to rock linearly or in rotation. A light source usable to the light source part 110 is not limited to the laser 112, and its lamps, such as 1 or two or more mercury lamps, and a xenon lamp, are also usable.
[0028]The beam plastic surgery system 114 can use a beam expander provided with two or more cylindrical lenses etc., for example, The shape of beam is fabricated to a desired thing by a thing (for example, sectional shape is made into a square from a rectangle) for which a horizontal-to-vertical ratio of a size of sectional shape of a parallel beam from the laser 112 is changed into a desired value. The beam shaping system 114 forms light flux with a size and an angle of divergence required to illuminate the optical integrator 140 mentioned later.
[0029]As for the light source part 110, although not shown in drawing 1, it is preferred to use the incoherent-ized optical system which makes coherent laser luminous flux incoherent. . As [indicate /, for example / the incoherent-ized optical system / by drawing 1 of the open patent Heisei 3(1991) No. 215930 gazette] They are at least two light flux (for example) in a light dividing side about an incoming beam. So that one light flux may be re-derived to a parting plane after giving the optical path length difference more than the coherence length of a laser beam to the light flux of another side via an optical member, and it may pile up with the light flux of another side and it may be ejected, after branching to p-polarized light and s-polarized light. An optical system provided with at least one clinch system carried out can be used.
[0030]The illumination-light study system 120 is provided with the following.
It is an optical system which illuminates the mask 200, and is the condensing optical system 130 at this embodiment.
Optical integrator 140.
Aperture diaphragm 150.
Condenser lens 160.
The illumination-light study system 120 can be used regardless of axial Uemitsu and axial outdoor daylight. The illumination-light study system 120 of this embodiment may have the masking blade and the scanning blade for changing the size of the transcriptional region on the plate 400. the illumination-light study system 120 of this embodiment has two or more lenses and required mirrors, and it is an injection side — a call — the afocal system which becomes centric is constituted.
[0031]The condensing optical system 130 introduces into the optical integrator 140 first the light flux which passed it efficiently including a required bending mirror, a lens, etc. For example, the condensing optical system 130, As the emission face of the beam shaping system 114, and an eye lens of the fly mentioned later. The condenser lens arranged so that the entrance plane of the constituted optical integrator 140 may become the relation (this relation may be called the relation of the Fourier transform with this application) between an object face and a pupil surface (or a pupil surface and the image surface) optically is included, The chief ray of the light flux which passed it is maintained in parallel to the center of the optical integrator 140, and every surrounding lens element 142.
[0032]The condensing optical system 130 contains further the light exposure controller 132 which can be changed for every Lighting Sub-Division for the light exposure of the illumination light to the mask 200. The light exposure controller 132 can change the beam cross section form of an incoming beam by changing each magnification of an afocal system. The light exposure controller 132 consists of zoom lenses etc., moves a lens to an optical axis direction, and may enable it to change angular magnification alternatively. If necessary, the light exposure controller 132 can divide an incoming beam with a half mirror, can detect light volume by a sensor, and can adjust the output of the laser 112, and/or a part of optical system based on this detection result. The light exposure controller 132 can also adjust the light volume ratio of the center section and periphery of the aperture diaphragm 150 which are mentioned later by replacing an optical element (for example, light volume adjustment (ND) filter), and/or changing image formation magnification with a zoom lens. The light exposure controller 132 can adjust a light exposure based on the contrast searched for in the pattern and/or said plate 400 of said request so that it may mention later. For example, what is necessary is for what is necessary to be just to enlarge relatively the ratio of the light exposure of the illumination light which has a peak in an optic axis, if pattern shape is thought as important, and just to enlarge relatively the ratio of the light exposure of the illumination light which has a peak of intensity distribution out of an axis, if contrast is thought as important. The light exposure controller 132 of this embodiment also has the function to adjust said peak position of the illumination light (large sigma Lighting Sub-Division) which has intensity distribution out of an axis.
[0033]For example, the exposure controller 132 makes it possible to use the circular opening diaphragm 150F as the aperture diaphragm 150 mentioned later shows to drawing 3 (F), when a center section as shown in drawing 2 creates the illumination light whose light intensity is higher than a periphery. Here, the center section of drawing 2 is the light intensity distribution of the illumination light whose light intensity is higher than a periphery. Drawing 3 (F) is an outline top view of the circular opening diaphragm 150F. In this application, "the illumination light using the illumination light which has a peak of intensity distribution near the optic axis" shall contain the illumination light as shown in drawing 2. The aperture diaphragm 150F comprises the circular light transmission section 155 of the transmissivity 1, and the shade part 152F of the shape of zona orbicularis of the transmissivity 0.
[0034]The optical integrator 140 equalizes illumination light illuminated by the mask 200, and it comprises this embodiment as an eye lens of a fly which changes angular distribution of incident light into position distribution, and emits it. As for an eye lens of a fly, the

entrance plane 140a and emission face 140b are maintained by relation of the Fourier transform. However, the optical integrator 140 with usable this invention is not limited to an eye lens of a fly so that it may mention later.
[0035]The eye lens 140 of a fly puts in order two or more lenses (lens element) 142 in another field where a mutual focal position differs from it. It is higher for utilization efficiency of illumination light for sectional shape of each lens element which constitutes an eye lens of a fly to be an illuminated field of a lighting system, and abbreviated similarity, when a lens side of each lens element is a surface of a sphere. This is because a light incidence face and an illuminated field of an eye lens of a fly are the relation (conjugation relation) between an object and an image.
[0036]Although an eye lens of a fly comprises this embodiment combining many lens elements of a square cross section according to form of the mask 200, this invention does not eliminate a lens element which has a round cross section, a rectangle, a hexagon, and other sectional shape. Each light flux from two or more point light sources (effective light source) formed in the emission face 140b of an eye lens of a fly or its neighborhood is superimposed on the mask 200 with the condenser lens 160. Thereby, the mask 200 whole is uniformly illuminated by much point light sources (effective light source).
[0037]The optical integrator 140 applicable by this invention may be replaced by the optical integrator 140A which it is not limited to an eye lens of a fly, for example, is shown in drawing 16. Here, drawing 16 is an expansion perspective view of the optical integrator 140A. The optical integrator 140A is constituted by piling up 2 sets of cylindrical lens array (or lenticular lens) boards 144 and 146. The cylindrical lens array boards 144a and 144b of a group of the 1st sheet and the 4th sheet have the focal distance f1, respectively, and the cylindrical lens array boards 146a and 146b of a group of the 2nd sheet and the 3rd sheet have the different focal distance f2 from f1. A cylindrical lens array board of the same group is arranged in a partner's focal position. 2 sets of cylindrical lens array boards 144 and 146 are arranged right-angled, and make light flux from which the f number (namely, the focal distance/effective aperture of a lens) differs in direction crossing at a right angle. It cannot be overemphasized that the number of groups of the optical integrator 140A is not limited to 2.
[0038]The eye lens 140 of a fly may be replaced by an optical rod. An optical rod makes uneven illuminance distribution uniform by an entrance plane in an emission face, and sectional shape vertical to a rod shaft has a rectangular cross section which has the almost same aspect ratio as an illuminated field. Since illumination in an emission face will not become uniform if an optical rod has power in sectional shape vertical to a rod shaft, sectional shape vertical to the rod shaft is a polygon formed only in a straight line. In addition, the eye lens 130 of a fly may be replaced by a diffraction element with a diffusion.
[0039]Just behind the emission face 140b of the optical integrator 140, the aperture diaphragm 150 to which form and a path were fixed is formed. The aperture diaphragm 150 of this embodiment has the aperture shape for illuminating the mask 200 using illumination light which has a peak of intensity distribution near the optic axis, and illumination light which has a peak of intensity distribution out of an axis (namely, it projects [whether these are projected one by one and] in the state where it compounded). Thus, this invention is included, also when preparing an aperture diaphragm which brings about illumination light which has a peak of intensity distribution near the optic axis, and an aperture diaphragm which brings about illumination light which has a peak of intensity distribution out of an axis, projecting one side of them on the mask 200 previously and projecting another side on the mask 200 after that. One of the features of this invention is solving many problems in accordance with exchange of the mask 200, and unless it is exchanged in the mask 200, it is because exchange of the aperture diaphragm 150 is not a problem. The aperture diaphragm 150 is formed in the pupil surface 320 of the projection optical system 300, and a conjugate position, and aperture shape of 150 of an aperture diaphragm is equivalent to an effective light source configuration of the pupil surface 320 of the projection optical system 300.
[0040]sigma is 0.3 or less and illumination light which has a peak of intensity distribution near the optic axis brings about interference of the zero-order diffracted light and the primary [**] diffracted light. sigma is 0.6 or more and illumination light which has a peak of intensity distribution out of an axis brings about interference of 2 light flux which consists of the zero-order diffracted light and the primary [+] primary [-] diffracted light. Here, sigma is NA by the side of the mask 200 of the illumination-light study system 120 to a numerical aperture (NA) by the side of the mask 200 of the projection optical system 300. Lighting Sub-Division which has a peak of intensity distribution near the optic axis may be called small sigma Lighting Sub-Division, usual Lighting Sub-Division, etc. Lighting Sub-Division which has a peak of intensity distribution out of an axis may be called large sigma Lighting Sub-Division, oblique incidence Lighting Sub-Division, deformation illumination, etc.
[0041]With reference to drawing 3 thru/or drawing 6, illustration form applicable to the aperture diaphragm 150 is explained. Here, drawing 3 thru/or drawing 6 are the outline top views of illustration form of the aperture diaphragm 150. Drawing 3 (A) is an outline top view of the aperture diaphragm 150A which has the circular opening 151 with a comparatively small radius for bringing about illumination light which has a peak of intensity distribution near the optic axis. The aperture diaphragm 150A has a light transmission section and the shade part 152A of the transmissivity 1 which comprise the circle 151.
[0042]Drawing 3 (B) is an outline top view of the aperture diaphragm 150B which has the light transmission section and the shade part 152B of the transmissivity 1 which consists of the circle 153 of a quadrupole for bringing about the illumination light which has a peak of intensity distribution out of an axis. A center position brings about the illumination light not more than sigma=1, and the circular opening 153 is arranged at **45 degrees and **135 degrees, respectively. Preferably, sigma of the illumination light which each circle 153 brings about is equal.
[0043]Drawing 3 (C) is an outline top view of the aperture diaphragm 150C which has the light transmission section and the shade part 152C of the transmissivity 1 which consists of the zona-orbicularis opening 154 for bringing about the illumination light which has a peak of intensity distribution out of an axis.
[0044]Drawing 3 (D) is an outline top view of the aperture diaphragm 150D which has the circular opening 151 shown in drawing 3 (A), and the circular opening 153 shown in drawing 3 (B) and which was constituted very much as a diaphragm for Lighting Sub-Division five-fold. The aperture diaphragm 150D follows and brings about the illumination light by which the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis were compounded. The circles 151 and 153 of the aperture diaphragm 150D have the same size. The aperture diaphragm 150D is provided with the following.
The light transmission section of the transmissivity 1 which consists of the circles 151 and 153.
The shade part 152D of the transmissivity 0.

[0045]Drawing 3 (E) is an outline top view of the aperture diaphragm 150E which has the zona-orbicularis opening 153 shown in the circular opening 151 shown in drawing 3 (A), and drawing 3 (C). Therefore, the aperture diaphragm 150E also brings about the illumination light by which the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis were compounded. The aperture diaphragm 150E is provided with the following.
The light transmission section of the transmissivity 1 which consists of the circles 151 and 154.
The shade part 152D of the transmissivity 0.

[0046]Various change, such as a part of quadrangle, other polygon, and sector, is possible for the form of the openings 151 and 153. sigma may exceed 1. This modification is explained with reference to drawing 4 and drawing 5. Here, drawing 4 (A) and (B) is an outline top view of the aperture diaphragms 150G and 150H which are the modifications of the aperture diaphragm 150D shown in drawing 3 (D). Drawing 4 (C) is an outline top view of the aperture diaphragm 150I which is a modification of the aperture diaphragm 150E shown in drawing 3 (E).
[0047]The aperture diaphragm 150G is provided with the following.
The light transmission section of the transmissivity 1 which consists of a little bigger circular opening 151A than the circular opening 151 and the rectangular opening 153A in which sigmasigma exceeded one selectively.
The shade part 152G of the transmissivity 0.
this invention person discovered that the pattern image formed in the plate 400 became clear, when sigma used the illumination light selectively exceeding one. The aperture diaphragm 150H is provided with the following.
The light transmission section of the transmissivity 1 which, as for the aperture diaphragm 150C, sigma becomes from the one or less circular opening 151 and the sector opening 153B.
The shade part 152H of the transmissivity 0.
The size of the sector opening 153B can be adjusted arbitrarily. The aperture diaphragm 150I is provided with the following.
The light transmission section of the transmissivity 1 which consists of the zona orbicularis (or rectangle belt) 154A selectively exceeding the circular opening 151 and sigma=1.
The shade part 152I of the transmissivity 0.
Since the function of the aperture diaphragm 150G thru/or I is the same as that of the above-mentioned aperture diaphragm 150D etc., detailed explanation is omitted here.
[0048]Kokonoe as another modification applicable to drawing 5 at the aperture diaphragm 150 -- the outline top view of the aperture diaphragm 150J constituted very much as a diaphragm for Lighting Sub-Division is shown. The aperture diaphragm 150J is provided with the following.
A little bigger circular opening 151B than the circular opening 151.
sigma of an opening position is the one or less circular opening 153C.
The light transmission section of the transmissivity 1 which consists of the circular opening 153D which sigma exceeds one selectively and has the same size as the circular opening 151B.
The shade part 152J of the transmissivity 0.
The circular opening 153C is formed in the position of 0 times, 90 degrees, 180 degrees, and 270 degrees, and the circular opening 153D is formed in the position of **45 degree and **135 degrees. Since the function of the aperture diaphragm 150J is also the same as that of the above-mentioned aperture diaphragm 150D etc., detailed explanation is omitted here.
[0049]What is necessary is to arrange the aperture diaphragms 150A thru/or 150J to a disc-like turret which is not illustrated, for example, and just to rotate a turret in the case of a change, in order to choose the desired aperture diaphragm 150 out of two or more kinds of aperture diaphragms 150. Thereby, first, out of illumination light which has a peak in an optic axis, and an axis, the lighting system 120 can illuminate the mask 200 by one side of the illumination light which has a peak of intensity distribution, and can illuminate the mask 200 by another side after that. In illumination light by which illumination light which has a peak in an optic axis, and illumination light which has a peak of intensity distribution out of an axis were compounded, the above-mentioned light exposure controller 132 can change each exposure ratio.
[0050]the condenser lens 160 collects as many lights which came out of the eye lens 140 of a fly as possible -- a chief ray -- parallel, i.e., a call, -- Koehler illumination of the mask 200 is carried out so that it may become centric. The mask 200 and the emission face 140b of the eye lens 140 of a fly are arranged at a relation of the Fourier transform.
[0051]If the exposure device 1 has necessity, it has a width variable slit for illumination unevenness control, a masking blade for exposure region restrictions under scan (a diaphragm or a slit), etc. a case where a masking blade is provided a masking blade and the emission face 140b of the eye lens 140 of a fly are arranged at a relation of the Fourier transform -- the 200th page of a mask -- engineering -- abbreviated -- it is provided in a conjugate position. Light flux which penetrated an opening of a masking blade is used as illumination light of the mask 200. A masking blade is the diaphragm which can carry out automatic variable [of the aperture width], and enables change of a transcriptional region (aperture slit) of the plate 400 mentioned later in a lengthwise direction. An exposure device may have further an above-mentioned masking blade and a scanning blade of a similar structure which enable change of a transverse direction of a transcriptional region (as the scan exposure field of one shot) of the plate 400. Aperture width is the diaphragm which can carry out automatic variable, and a scanning blade is also formed in the 200th page of a mask, and an optical almost conjugate position. Thereby, the exposure device 1 can set up a size of a transcriptional region according to a size of a shot exposed by using these two variable blades.
[0052]The mask 200 is a product made from quartz, and the circuit pattern (or image) which should be transferred is formed on it, and it is supported and driven to the mask stage which is not illustrated, for example. The diffracted light emitted from the mask 200 is projected on the plate 400 through the projection optical system 300. The plate 400 is a processed object and the resist is applied. The mask 200 and the plate 400 are arranged optically at a conjugate relation. Since the exposure device 1 of this embodiment is an exposure device (namely, scanner) of a step and scanning method, it transfers the pattern of the mask 200 on the plate 400 by scanning the mask 200 and the plate 400. If it is an exposure device (namely, "stepper") of a step and repeat system, it will expose in

the state where the mask 200 and the plate 400 were made to stand it still.
[0053]The mask stage is connected to the moving mechanism which is not illustrated in support of the mask 200. A mask stage and the projection optical system 300 are established on the stage body tube surface plate supported via a damper etc. by the base frame laid in the floor etc., for example. The mask stage can apply any composition of this business world well-known. The moving mechanism which is not illustrated comprises a linear motor etc. and the mask 200 can be moved to an XY direction by driving a mask stage. The exposure device 1 is scanned in the state where it synchronized according to the control mechanism which does not illustrate the mask 200 and the plate 400.
[0054]The mask 200 as a one side face of this invention has a desired pattern and a pattern of a dummy with periodicity put on the pattern concerned. A portion which should be made to resolve by an effect of a dummy pattern among desired patterns is formed as a phase shift mask made thicker than line width of a pattern of said dummy. For example the mask concerned forms a desired pattern, piles up a pattern of a dummy which has periodicity in the pattern concerned, and is manufactured as a phase shift mask by making some patterns of said request thicker than a pattern of said dummy. Some desired patterns are made thick in order to provide a difference in a light exposure with a dummy pattern, so that it may mention later.
[0055]In order to explain pattern constitution of the mask 200 of this invention, a desired pattern is explained first. Here, let a desired pattern be the gate pattern 20 as shown in drawing 6, for example. Here, drawing 6 is an outline top view of the desired pattern 20.
[0056]The gate pattern 20 comprises the pattern parts 21a and 21b (unless it refuses in particular, the reference number 21 summarizes both.) of a couple, and each pattern part 21 comprises the detailed gate section 22 passing through B section, and the two contact parts 24 passing through A section. The gate pattern 20 is constituted by chromium etc., for example.
[0057]As shown in drawing 6, both the gate sections 22 are rectangles which have the respectively detailed line width L, and have aligned in parallel at intervals of [detailed] L. If it puts in another way, the gate section 22 constitutes the L&S pattern selectively. In this embodiment, L is 0.12 micrometer.
[0058]The contact part 24 is a rectangle which has the line width 3L respectively in illustration, and two pairs of contact parts 24 have aligned in parallel via the detailed interval L. The two contact parts 24 are formed in the both ends of the gate section 22 at each pattern part 21. An object of this invention is to resolve simultaneously the contact part 24 with which line width detailed in this way and interval separated the equal (to L) gate section 22, and the detailed interval L, and large line width (namely, 3L) was located in a line compared with the minimum line width (gate section 22) L. It depends for the suitable line width L for this invention on the wavelength lambda of k_1 shown in the expression 1, and a light source, and NA of a projection optical system. For example, when a KrF excimer laser with a wavelength of 248 nm and the projection optical system of NA=0.6 are used, the theoretical resolving R is set to 103 nm from the expression 1 as k_1=0.25, if it is NA=0.85, it will be set to R= 73 nm and this will be set to L. To the neighborhood, using an ArF excimer laser with a wavelength of 193 nm, if it is NA=0.85, it will be set to R= 57 nm again, and this is set to L. k_1 can change from 0.25 to about 0.5 (or more than it).
[0059]In order to resolve the two gate sections 22 first, the pattern which forms two or more patterns of the periodic dummy of fine lines and a detailed interval with an identical pitch in the both sides of the two gate sections 22, and has a periodic structure is formed. By adding a dummy pattern and forming a periodic structure, control with the sufficient improvement in resolution performance and accuracy of line width is attained. This periodic pattern acquires ultimate resolution with a phase shift mask.
[0060]An example of the phase shift mask 50 which has the mask pattern 40 formed by putting the dummy pattern 30 on the desired pattern 20 is shown in drawing 7. As shown in the figure, the desired pattern 20 comprises the pattern part 21 of a couple, as mentioned above. The dummy pattern 30 has the parallel light transmission sections 32 and 34 and the shade part 36 mutually, and a light transmission section and the shade part 36 align by turns. The width of each direction of Y of the light transmission sections 32 and 34 and the shade part 36 is equal to L (this embodiment 0.12 micrometer) shown in drawing 6. The phase was set as 0 times and 180 degrees, the light transmission sections 32 and 34 are reversed 180 degrees mutually, and the light transmission sections 32 and 34 have aligned in the direction of Y by turns. The light transmission sections 32 and 34 have the transmissivity 1 (or 100%), and the shade part 36 has the transmissivity 0. The shade part 36 is constituted by chromium etc., for example.
[0061]The gate section 22 of each pattern part 21 is laid on top of the shade part 36 of the dummy pattern 30. Although it may be grasped as some desired patterns 20 between the two gate sections 22, a phase is grasped here as the light transmission section 34 set as 180 degrees. Each contact part 24 is provided with the following.
The shade parts 24a and 24c.
The light transmission section 24b which the light transmission section 32 piled up.
That is, the field's 24b reference of drawing 6 and drawing 7 will understand changing from a shade part to a light transmission section by having piled up the dummy pattern 30. Transmissivity of the light transmission section 24b is 1 (100%), and transmissivity of the shade parts 22, 24a, and 24c is 0.
[0062]Next, Lighting Sub-Division which uses illumination light which has a peak of intensity distribution near the optic axis (it is (for example, like illumination light which the aperture diaphragm 150A shown in drawing 3 (A) brings about)), (It is for example, like illumination light which the aperture diaphragm 150B shown in drawing 3 (B) brings about) it produces as the sum with illumination light which has a peak of intensity distribution out of an axis -- multiplex illumination-light (for example, illumination light which aperture diaphragm 150D shown in drawing 3 (D) brings about) use was carried out, and the phase shift mask 50 was exposed. At this time, a result of light intensity distribution produced on the plate 400 mentioned later is shown in drawing 8.
[0063]Drawing 8 (A) is the light intensity distribution on the plate 400 about a section including A section shown in drawing 6. Drawing 8 (B) is the light intensity distribution on the plate 400 about a section including A section shown in drawing 6. The intensity distribution on the plate 400 can be interpreted as the exposure value distribution of the resist of the plate 400. With reference to drawing 8 (A), about A section, the light intensity of the light transmission section 24b is too high, and it is understood that the contact part 24 is not correctly transferred by the plate 400. It is understood that the dummy pattern 30 remains and the gate section 22 is not correctly transferred by the plate 400 even if it shakes various threshold values of the resist of the plate 400 mentioned later about B section with reference to drawing 8 (B).
[0064]Then, by fattening the gate section 22 (namely, detailed portion) of the desired pattern 20 for a while, it distinguishes between a light exposure with the dummy pattern 30, the desired pattern 20 is emphasized, and the desired pattern 20 was resolved by the

plate 400. The phase shift mask at this time is the mask 200 as a one side face of this invention. Hereafter, the phase shift mask 200 is explained with reference to drawing 9. Here, drawing 9 (A) is an outline top view of the phase shift mask 200. Drawing 9 (B) is the elements on larger scale of the phase shift mask 200. Drawing 9 (C) is a modification of the phase shift mask 200 shown in drawing 9 (B). As shown in the figure, the phase shift mask 200 has the mask pattern 260 in which a part comprises the pattern 210 of the request made thick, and the dummy pattern 240.
[0065]Although the desired pattern 210 is similar to the gate pattern 20, it is different in that a part is made thick. The desired pattern 210 comprises the pattern parts 212a and 212b (unless it refuses in particular, the reference number 212 summarizes both.) of a couple, and each pattern part 212 comprises the detailed gate section 220 passing through D section, and the two contact parts 230 passing through C section.
[0066]Both the gate sections 220 are rectangles which have respectively detailed line width (it is the large line width L1 somewhat from L), and have aligned in parallel at a detailed interval (it is a small interval somewhat from L). In this embodiment, L is 0.12 micrometer.
[0067]On the other hand, respectively in illustration, rather than the line width 3L, the contact part 230 is a rectangle which has big line width somewhat, and has aligned in parallel via an interval (it is a small interval somewhat from L) with two pairs of detailed contact parts. The two contact parts 230 are formed in both ends of the gate section 220 at each pattern part 212. This invention separates the almost equal gate section 220 and a detailed interval (it is a small interval somewhat from L), and line width detailed in this way and an interval compared with the minimum line width (gate section 220) L Large line width. (namely, it aims at resolving simultaneously the contact part 230 with which big line width) was somewhat located in a line rather than 3L.
[0068]In order to resolve the two gate sections 220, two or more dummy patterns 240 are formed in the both sides of the two gate sections 220, and have a periodic structure of the fine lines which have identical pitch L and a detailed interval. By adding the dummy pattern 240 and forming a periodic structure, control with the sufficient improvement in resolution performance and accuracy of line width is attained. This periodic pattern acquires ultimate resolution with a phase shift mask.
[0069]The dummy pattern 240 has the parallel light transmission sections 242 and 244 and the shade part 246 mutually, and a light transmission section and the shade part 246 align by turns. The width of each direction of Y of the light transmission sections 242 and 244 and the shade part 246 is equal to L (this embodiment 0.12 micrometer). The phase was set as 0 times and 180 degrees, the light transmission sections 242 and 244 are reversed 180 degrees mutually, and the light transmission sections 242 and 244 have aligned in the direction of Y by turns. The shade part 246 is constituted by chromium etc., for example. The transmissivity of the light transmission sections 242 and 244 is 1 (100%), and the transmissivity of the shade part 246 is 0.
[0070]The gate section 220 of each pattern part 212 is laid on top of the shade part 246 of the dummy pattern 240. Although it may be grasped as some desired patterns 210 between the two gate sections 220, the phase is grasped here as the light transmission section 244 set as 180 degrees. Each contact part 230 is provided with the following.
Shade parts 232 and 236.
The light transmission section 234 which the light transmission section 242 piled up.
That is, the field 234 is changing from the shade part to the light transmission section, when the dummy pattern 240 piled up. The transmissivity of the light transmission section 234 is 1 (100%), and the transmissivity of the shade parts 220, 232, and 236 is 0.
[0071]As shown in drawing 9 (A), originally, what was L respectively is large to L1 (>L), and the line width of the gate section 220 and the shade parts 232 and 236 of the contact part 230 is carried out. With reference to drawing 9 (B), about the center lines U1 and U2 of the shade part 246, it is equal, only L2 is thick on the outside, and each of the shade parts 232 and 236 is carried out. As a result, it is understood that L1 is L+2xL2. It is understood that the line width of the field 234 is L-2xL2. Unlike this embodiment, the shade parts 232 and 236 may be made thick by asymmetric width about the center lines U1 and U2, respectively, and as shown in drawing 9 (C), they may be made thick by one side on either side, for example. The line width by which the shade part 232 is made thick may differ from the line width by which the shade part 236 is made thick. The Reason for making the shade parts 232 and 236 thick in this way is for establishing a difference for the desired pattern 210 about a light exposure from the dummy pattern 240. The ratio of the line width L1 which should be made thick to the line width L is about (for example, about 17%) tens of %, for example.
[0072]According to this embodiment, since the line width of the gate section 220 is the same as that of the shade part 232 (namely, this example L+2xL2), explanation is omitted here. It is good selectively as for what is different from the shade part 232 in the line width of the gate section 220, and the gate section 220 may be made thick to right-and-left asymmetry about Chuo Line U1.
[0073]Next, Lighting Sub-Division which uses the illumination light which has a peak of intensity distribution near the optic axis (it is (for example, like the illumination light which the aperture diaphragm 150A of the illumination light shown in drawing 3 (A) brings about)), (It is for example, like the illumination light which the aperture diaphragm 150B shown in drawing 3 (B) brings about) it produces as the sum with the illumination light which has a peak of intensity distribution out of an axis -- multiplex illumination-light (for example, illumination light which aperture diaphragm 150D shown in drawing 3 (D) brings about) use was carried out, and the phase shift mask 200 was exposed. At this time, the result of the light intensity distribution produced on the plate 400 mentioned later is shown in drawing 10.
[0074]Drawing 10 (A) is the light intensity distribution on the plate 400 about a section including C section shown in drawing 9 (A). Drawing 10 (B) is the light intensity distribution on the plate 400 about a section including D section shown in drawing 9 (A). The intensity distribution on the plate 400 can be interpreted as the exposure value distribution of the resist of the plate 400. It is understood in drawing 10 (A) that the light intensity of the light transmission section 234 is decreasing rather than the light transmission section 24b about C section as compared with drawing 8 (A). This is because the line width of the light transmission section 234 became smaller than L (L-2xL2). For this reason, if the threshold value of a resist is shaken suitably, it will be understood that the contact part 230 can transfer on the plate 400. It is understood in drawing 10 (B) that the light intensity of the light transmission section 244 between the gate sections 220 is decreasing rather than the light transmission section 34 between the gate sections 22 about D section as compared with drawing 8 (B). This is because the line width of the light transmission section 244 between the gate sections 220 became smaller than L (L-2xL2). For this reason, if the threshold value of a resist is shaken suitably, it will be understood that the gate section 220 can transfer on the plate 400. As mentioned above, if the threshold value of a resist is shaken suitably, it will be understood that the desired pattern 210 can transfer on the plate 400 correctly.
[0075]Next, with reference to drawing 12, the mask 200A as a modification of the mask 200 is explained. Here, drawing 12 is an

outline top view of the mask 200A. The mask 200A has the mask pattern 260A which comprises the desired pattern 210 and the dummy pattern 240A, as shown in the figure. Since the desired pattern 210 is the same as that of drawing 9, explanation is omitted.
[0076]The dummy pattern 240A comprised the light transmission sections 242A and 244A, the phase was set as 0 times and 180 degrees, and both have reversed it 180 degrees. The light transmission sections 242A and 244A had the width 2L in the direction of Y, respectively, and have aligned in parallel [by turns] with the direction of Y. Thus, the dummy patterns 240A of this embodiment differ in the dummy pattern 240 shown in drawing 9, and do not have a shade part. Therefore, it becomes only the desired pattern 210 to have a shade part which comprises chromium etc. It is possible to distinguish between the light exposure of the desired pattern 210 and the dummy pattern 240A by such chromium loess composition.
[0077]That is, it will be understood that a light exposure of a center section of drawing 8 (A) decreases like a light exposure shown in a center section of drawing 10 (A) since width of the light transmission section 234 is smaller than width of the light transmission sections 242A and 244A. Since similarly width of the light transmission section 244A (and light transmission section 244A sandwiched by the gate section 220 of a couple) sandwiched by two pairs of shade parts 232 is smaller than width of the light transmission sections 242A and 244A, It will be understood that a light exposure of a center section of drawing 8 (B) decreases like a light exposure shown in a center section of drawing 10 (B). As a result, the desired pattern 210 can be transferred with sufficient contrast on the plate 400.
[0078]It will be understood that the same effect is acquired, even if the line width of the boundary part which a phase reverses in the desired pattern 210 is set up suitably and it controls the light exposure of the desired pattern 210 and the dummy pattern 240 the optimal.
[0079]Next, with reference to drawing 14, the mask 200B as a modification of the mask 200 is explained. Here, drawing 14 is an outline top view of the mask 200B. The mask 200B has the mask pattern 260B which comprises the desired pattern 210A and the dummy pattern 240A, as shown in the figure. Since it is the same as that of drawing 12, the dummy pattern 240A omits explanation.
[0080]As shown in drawing 14, the desired pattern 210 consists of the pattern parts 214a and 214b (unless it refuses in particular, the reference number "214" shall summarize these) of a couple, and each pattern part 214 comprises the gate section 220 and the contact part 230A of a couple. Each contact part 230A has the light transmission section 234A and the shade parts 232 and 236. Since the gate section 220 and the shade parts 232 and 236 are the same as that of what was mentioned above with reference to drawing 9, explanation is omitted here.
[0081]As for the light transmission section 234A, transmissivity is set as 0.7 (70%) instead of 1 (100%). It is possible for this to distinguish between the light exposure of the desired pattern 210A and the dummy pattern 240A. That is, it will be understood that the light exposure of the center section of drawing 8 (A) decreases like the light exposure shown in the center section of drawing 10 (A), since the width of the light transmission section 234A is smaller than the width of the light transmission sections 242A and 244A and transmissivity is also low.
[0082]If the light transmission section 234A is used, it will be understood that the dummy pattern 240A may be the dummy pattern 240. Of course, the transmissivity of the light transmission section 244A (and light transmission section 244A sandwiched by the gate section 220 of the couple) sandwiched by two pairs of shade parts 232 may be similarly set as 0.7 (70%).
[0083]Thus, the desired pattern 210 can be transferred with sufficient contrast on the plate 400 by controlling a part of (between the pattern parts 212 is included) light transmittance of a desired pattern.
[0084]The projection optical system 300 has the aperture diaphragm 320 for carrying out image formation of the diffracted light which passed through the mask pattern 260 formed in the mask 200 on the plate 400. The optical system which the projection optical system 300 turns into only from two or more lens elements, the optical system which has two or more lens elements and a concave mirror of at least one sheet (catadioptric optical system), The optical system which has two or more lens elements and diffraction optical elements, such as kino form of at least one sheet, an all the mirrors type optical system, etc. can be used. When amendment of a chromatic aberration is required, two or more lens elements which consist of a glass material with which variances (Abbe value) differ mutually are used, or it constitutes so that distribution of a lens element and an opposite direction may produce a diffraction optical element. As mentioned above, the form of the effective light source formed in the pupil surface 320 of the projection optical system 300 is the same as the form shown in drawing 3 thru/or drawing 5.
[0085]Although the plate 400 is a wafer in this embodiment, it includes another liquid crystal substrate and processed object widely. Photoresist is applied to the plate 400. A photoresist application process is provided with the following.
Pretreatment.
Adhesiveness improver coating treatments.
Photoresist coating treatments.
Prebaking processing.
Pretreatment includes washing, desiccation, etc. adhesiveness improver coating treatments are surface treatment (namely, hydrophobicity-izing by surface-active agent spreading) processing for improving the adhesion of photoresist and a ground -- organic layers, such as HMDS (Hexamethyl-disilazane), -- a coat -- or it steams. Although prebaking is a baking powder (calcination) process, it is softer than it after development, and it removes a solvent.
[0086]The plate 400 is supported by the wafer stage 450. Since any composition of well-known in this industry is applicable, the stage 450 omits explanation of a detailed structure and operation here. For example, the stage 450 moves the plate 400 to an XY direction using a linear motor. It is scanned synchronously, the position of the mask stage and the wafer stage 450 which are not illustrated is supervised by a laser interferometer etc., for example, and both drive the mask 200 and the plate 400 at the fixed rate of a velocity ratio. The stage 450 is formed on the stage surface plate supported on a floor etc. via a damper, for example, and a mask stage and the projection optical system 300 are established on the body tube surface plate with which a body tube surface plate is supported via a damper etc. on the base frame laid in the floor etc. and which is not illustrated, for example.
[0087]It is made to move to a Z direction which is connected to the stage 450 and shows drawing 1 the plate 400 within the limits of the depth of focus with the stage 450, and the image formation position adjustment 500 adjusts an image formation position of the plate 400. If the exposure device 1 has necessity, it can also lose dispersion in image formation performance in the depth of focus by exposing two or more times to the plate 400 arranged at a different position in a Z direction. Since any well-known technology is applicable in this industry, such as a rack which is extended to a Z direction and which is not illustrated, and a means for it to be

connected to the stage 450 and to rotate a movable pinion which is not illustrated and a pinion for a rack top, the image formation position adjustment 500 omits detailed explanation here.

[0088]In exposure, light flux emitted from the laser 112 enters into the illumination-light study system 120, after the shape of beam is fabricated by desired thing by the beam shaping system 114. The condensing optical system 130 introduces into the optical integrator 140 efficiently light flux which passed it. In that case, the light exposure controller 132 adjusts a light exposure of illumination light. The optical integrator 140 equalizes illumination light and the aperture diaphragm 150 forms illumination light by which illumination light which has a peak of intensity distribution near the optic axis, and illumination light which has a peak of intensity distribution out of an axis were compounded. This illumination light illuminates the phase shift mask 200 on optimal Lighting Sub-Division conditions via the condenser lens 160.

[0089]The mask pattern 260 in which a part of line width comprised the pattern 210 of the request made thick and the dummy pattern 240 put on the pattern 210 is formed in the mask 200. The gate section 220 is put on the shade part (dark line part) 236 of the dummy pattern 240, and forms a L&S pattern with the dummy pattern 240, and resolution performance is raised by the phase shift mask. The gate section 220 is made thicker than the dummy pattern 240, and, as for the light transmission section in the meantime, the light exposure is decreasing rather than the dummy pattern 240. Put the contact part 230 on the dummy pattern 240, and in part. (Namely, the field 234) changes to a light transmission section, a part (namely, shade parts 232 and 236) is made thicker than the line width of the dummy pattern 240, and, as a result, in the light transmission section 234, the light exposure is decreasing rather than the dummy pattern 240.

[0090]Reduction projection of the light flux which passed the mask 200 is carried out by image formation operation of the projection optical system 300 for predetermined magnification on the plate 400. If it is the exposure device 1 of a step and scanning method, it will fix, the mask 200 and the plate 400 will carry out a synchronous scan, and the light source part 110 and the projection optical system 300 will expose the whole shot. The step of the stage 450 of the plate 400 is carried out, it moves to the following shot, and exposure transfer of many shots is carried out on the plate 400. If the exposure device 1 is a step and repeat system, it will expose in the state where the mask 200 and the plate 400 were made to stand it still.

[0091]The illumination light which has a peak of intensity distribution near the optic axis illuminates the phase shift mask 200, and forms the intensity distribution of a detailed period pattern on the plate 400. The illumination light which has a peak of intensity distribution out of an axis illuminates the mask 200, and exposes it coarsely. Since the light transmission sections 244 and 234 between the gate sections 220 of the phase shift mask 200 have narrow pattern width, a light exposure decreases, and the desired pattern 210 is contributed to dissociating from the dummy pattern 240. As a result, the pattern of the desired contact hole 210 can be formed on the plate 400 by choosing the threshold value of the resist of the plate 400 suitably. Thereby, the exposure device 1 can perform pattern transfer to a resist with high precision, and can provide high-definition devices (a semiconductor device, an LCD element, image sensors (CCD etc.), a thin film magnetic head, etc.).

[0092]Next, with reference to drawing 17 and drawing 18, the embodiment of the manufacturing method of the device using the above-mentioned exposure device 1 is described. Drawing 17 is a flow chart for explaining manufacture of devices (semiconductor chips, such as IC and LSI, LCD, CCD, etc.). Here, manufacture of a semiconductor chip is explained to an example. The circuit design of a device is performed at Step 1 (circuit design). The mask in which the designed circuit pattern was formed is manufactured in Step 2 (mask manufacture). At Step 3 (wafer manufacture), a wafer is manufactured using materials, such as silicon. Step 4 (wafer process) is called a previous process, and forms a actual circuit on a wafer with the lithography technology of this invention using a mask and a wafer. Step 5 (assembly) is called a post process, is a process semiconductor-chip-ized using the wafer created by Step 4, and includes processes, such as an assembly process (dicing, bonding) and a packaging process (chip enclosure). In Step 6 (inspection), the operation confirming test of the semiconductor device created at Step 5, an endurance test, etc. are inspected. A semiconductor device is completed through such a process and this is shipped (Step 7).

[0093]Drawing 18 is a detailed flow chart of the wafer process of Step 4. The surface of a wafer is oxidized at Step 11 (oxidation). In Step 12 (CVD), an insulator layer is formed on the surface of a wafer. In Step 13 (electrode formation), an electrode is formed by vacuum evaporation etc. on a wafer. Ion is driven into a wafer at Step 14 (ion implantation). A sensitizing agent is applied to a wafer at Step 15 (resist process). In Step 16 (exposure), the circuit pattern of a mask is exposed to a wafer with the exposure device 1. The exposed wafer is developed in Step 17 (development). In Step 18 (etching), portions other than the developed resist image are shaved off. The resist which etching ended and became unnecessary is removed in Step 19 (resist removing). A circuit pattern is formed on a wafer by carrying out by repeating these steps multiplex.

[0094]

[Work example 1]In Embodiment 1, the phase shift mask 200 shown in drawing 9, the aperture diaphragm 150G indicated to be a KrF excimer laser (wavelength of 248 nm) to drawing 4 (A) at the laser 112, and the projection optical system 300 of NA0.60 were used for the exposure device 1. In the phase shift mask 200, L shown in drawing 9 (B) set L1 to 140 nm (namely, L2=10nm) at 120 nm by conversion on a wafer (plate 400) side. The dummy pattern 240 was used as a 120-nm L&S pattern.

[0095]The illumination light which has a peak of intensity distribution for this exposure device 1 near the optic axis (it is (like the illumination light which the aperture diaphragm 150A shown in drawing 3 (A) gives)), (It is like the illumination light which the aperture diaphragm 150B shown in drawing 3 (B) gives) the quadrupole illumination light (sigma of the center position of each circular opening -- x.) which has a peak of intensity distribution out of an axis sigma of the size of each circular opening is set to 0.3 at the position of each y direction 0.6. And it exposed, respectively by the fivefold (it is (like illumination light which aperture diaphragm 150D shown in drawing 3 (D) gives)) pole illumination light (0.3 and the others of sigma of the central part are the same as that of the quadrupole illumination light) by which the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis were compounded. The intensity ratio of the illumination light which has a peak of intensity distribution near the optic axis of the fivefold pole illumination light by the light exposure controller 132, and the illumination light which has a peak of intensity distribution out of an axis was set as 0.9 to 1.

[0096]The result of these exposure is shown in drawing 11. When the illumination light which has a peak of intensity distribution near the optic axis is used with reference to drawing 11 (A), only minute periodical structure is exposed. When the quadrupole illumination light is used with reference to drawing 11 (B), only a big pattern part is exposed and the detailed period pattern is not resolved. When the fivefold pole illumination light which carried out multiplex [of these] is used with reference to drawing 11 (C), the gate pattern

210 desired whole is resolved. Drawing 11 (A) thru/or (C) is the exposure pattern characteristic at the time of shaking the distance from the focus in the depth of focus at a transverse direction to -0.4micrometer-+0.4micrometer with the resolving centering control equipment 500. These brought the same result as what was explained with reference to drawing 10.

[0097]When the fivefold pole illumination light was used, as shown in drawing 11 (C), a 0.12-micrometer pattern with the very sufficient definition of a detailed pattern was formed. When the line width R in the expression 1 is broken by (lambda/NA) and it standardizes by k_1, it means that the pattern of k_1=0.29 was resolved.

[0098]

[Work example 2]In Embodiment 2, the phase shift mask 200A shown in drawing 12 was used, the aperture diaphragm 150D was used for the aperture diaphragm 150, and both the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis were used at it. Other exposing conditions were made to be the same as that of Embodiment 1. The result at this time is shown in drawing 13. It will be understood that the same result as drawing 11 (C) is obtained.

[0099]

[Work example 3]In Embodiment 3, the phase shift mask 200B shown in drawing 14 was used. Other exposing conditions were made to be the same as that of Embodiment 2. The result at this time is shown in drawing 15. It will be understood that the same result as drawing 11 (C) is obtained.

[0100]According to this invention, minimum line width was able to transfer with the sufficient imaging characteristic in a different position in the depth of focus on the 400th page of the plate, without a detailed complicated pattern of 0.15 micrometer or less exchanging the mask 200. In both this examples, the pattern whose minimum line width and minimum interval are 0.12 micrometer was resolved with the KrF excimer laser and the exposure device 1 of NA=0.6. When resolution is standardized by k_1, it is k_1=0.29 and pitch 0.29x2=0.58. Therefore, it became possible to expose without resolving of the complicated pattern which consists of detailed line width and bigger line width than it exchanging masks, and formation of the predetermined pattern was attained on the wafer surface.

[0101]As mentioned above, although the desirable embodiment of this invention was described, the various modification and change of the meaning at within the limits are possible for this invention for not being limited to these.

[0102]

[Effect of the Invention]According to the mask, the exposure method, and equipment of this invention, it can have detailed line width (for example, 0.15 micrometer or less), and the mask pattern in which even from a L&S pattern to isolation and a complicated pattern are intermingled can be exposed to high resolution, without exchanging masks. The device manufacturing method which uses this exposure method and equipment can manufacture a high-definition device.

[Translation done.]

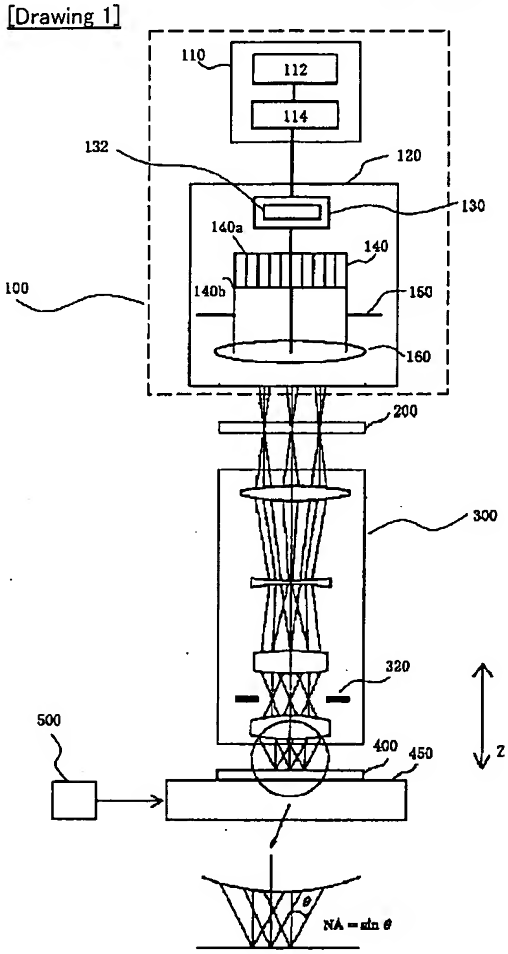
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a schematic block diagram of the exposure device of this invention.
[Drawing 2]It is the light intensity distribution which shows an example of the illumination light which can adjust the light exposure controller of the exposure device shown in drawing 1.
[Drawing 3]It is an outline top view of the illustration form of the aperture diaphragm of the exposure device shown in drawing 1.
[Drawing 4]It is an outline top view of another illustration form of the aperture diaphragm shown in drawing 1.
[Drawing 5]It is an outline top view of another illustration form of the aperture diaphragm shown in drawing 1.
[Drawing 6]It is an outline top view of a desired pattern.
[Drawing 7]It is an example of the phase shift mask formed by putting a dummy pattern on the pattern shown in drawing 6.
[Drawing 8]It is the light intensity distribution produced on the plate shown in drawing 1 at the time of illuminating the phase shift mask shown in drawing 7 using the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis.
[Drawing 9]It is an outline top view of the phase shift mask of this invention.
[Drawing 10]When the mask shown in drawing 9 using the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis is illuminated, it is the light intensity distribution which appears in the plate of the exposure device shown in drawing 1.
[Drawing 11]It is the pattern transferred by the plate at the time of illuminating the phase shift mask shown in drawing 9 on different Lighting Sub-Division conditions as an exposing result of Embodiment 1.
[Drawing 12]It is an outline top view of the modification of the phase shift mask shown in drawing 9.
[Drawing 13]It is the pattern transferred by the plate at the time of illuminating the phase shift mask shown in drawing 12 on different Lighting Sub-Division conditions as an exposing result of Embodiment 2.
[Drawing 14]It is an outline top view of another modification of the phase shift mask shown in drawing 9.
[Drawing 15]It is the pattern transferred by the plate at the time of illuminating the phase shift mask shown in drawing 14 on different Lighting Sub-Division conditions as an exposing result of Embodiment 3.
[Drawing 16]It is an expansion perspective view of the modification of the optical integrator of the exposure device shown in drawing 1.
[Drawing 17]It is a flow chart for explaining the device manufacturing method which has an exposure device of this invention.
[Drawing 18]It is a detailed flow chart of Step 4 shown in drawing 17.
[Explanations of letters or numerals]
1 Exposure device
100 Lighting system
120 Illumination-light study system
132 Light exposure controller
150 Aperture diaphragm
200 Mask
210 A desired pattern
240 A dummy pattern
260 Mask pattern
300 Projection optical system
320 Pupil
400 Plate

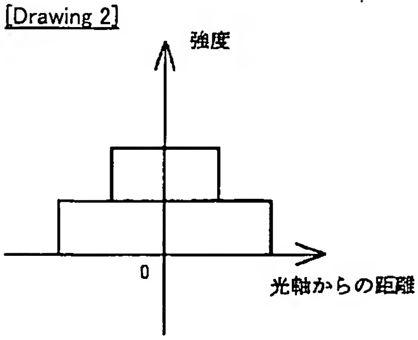
[Translation done.]

DRAWINGS

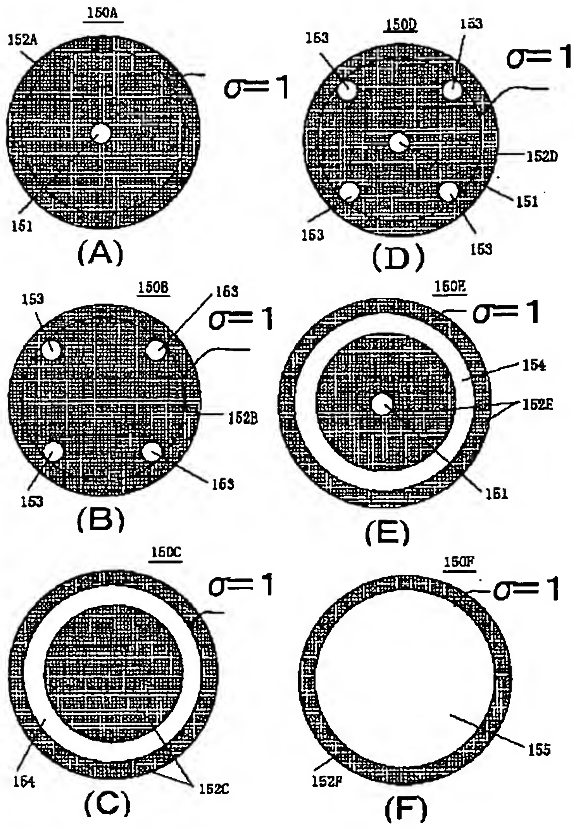
[Drawing 1]



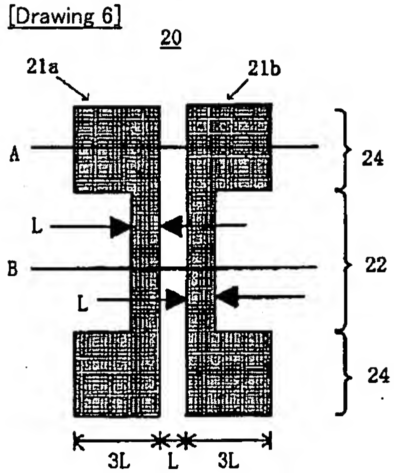
[Drawing 2]



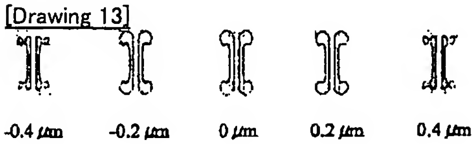
[Drawing 3]



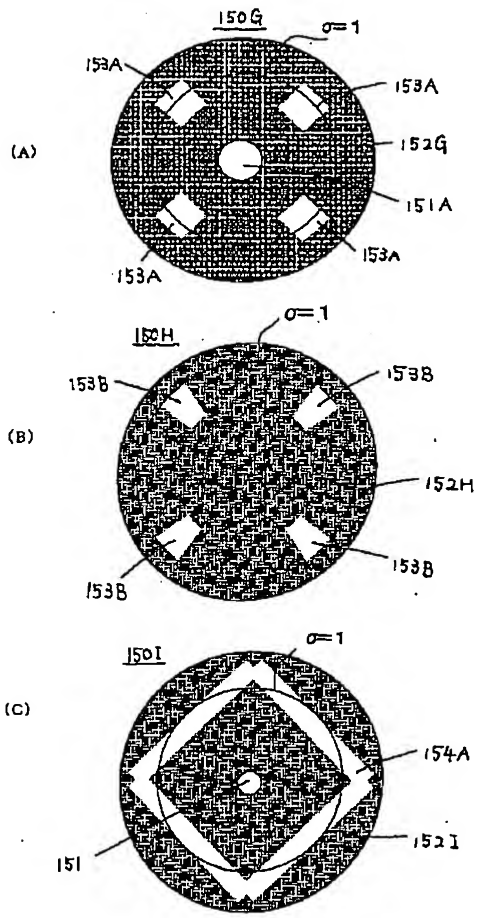
[Drawing 6]



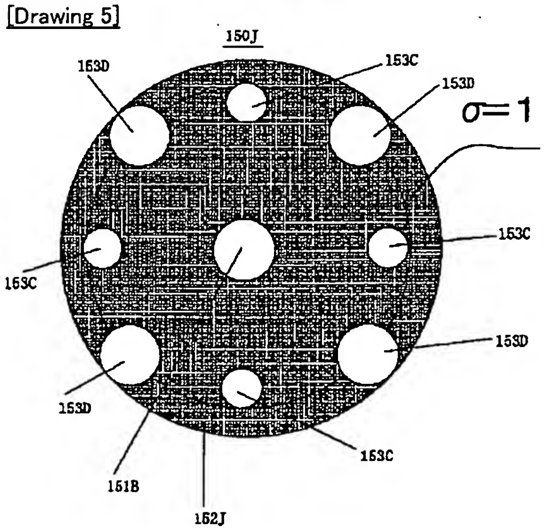
[Drawing 13]



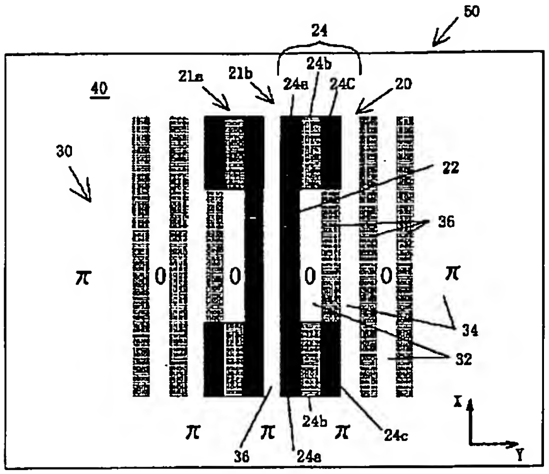
[Drawing 4]



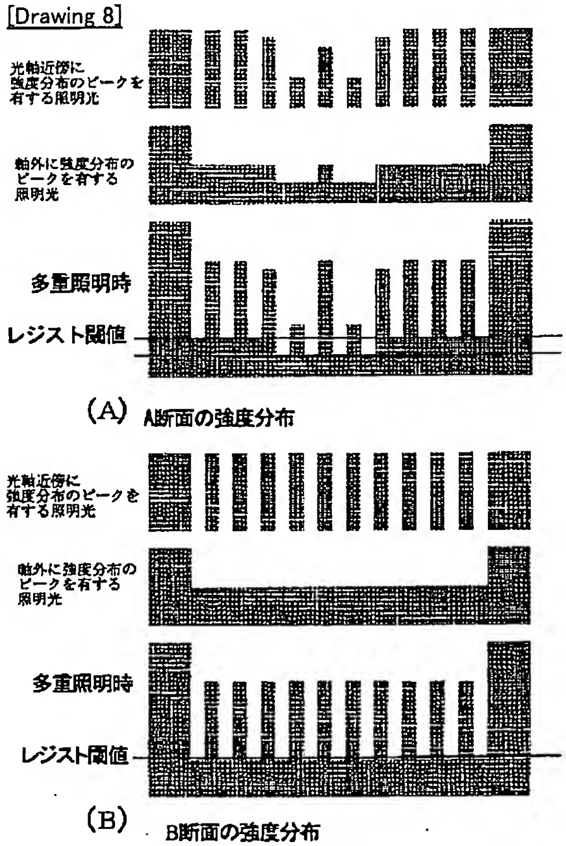
[Drawing 5]



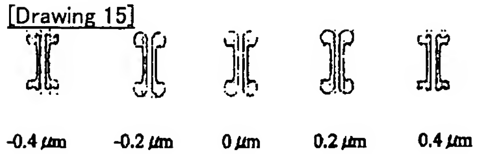
[Drawing 7]



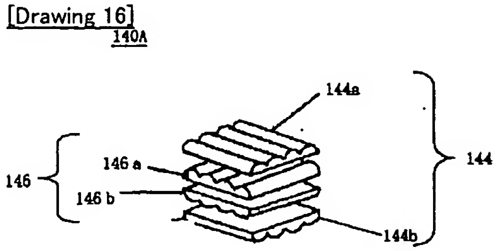
[Drawing 8]



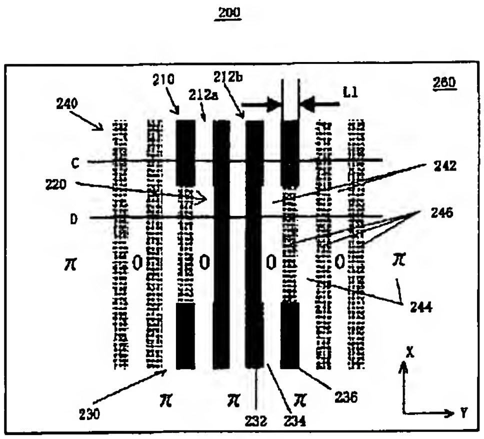
[Drawing 15]



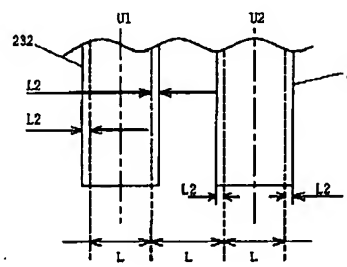
[Drawing 16]



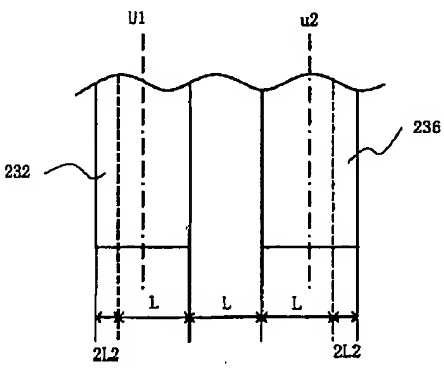
[Drawing 9]



(A)

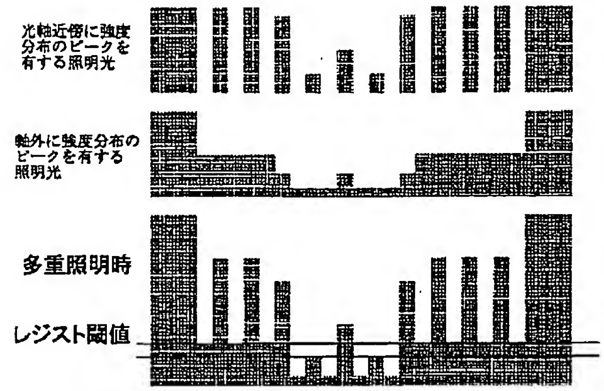


(B)

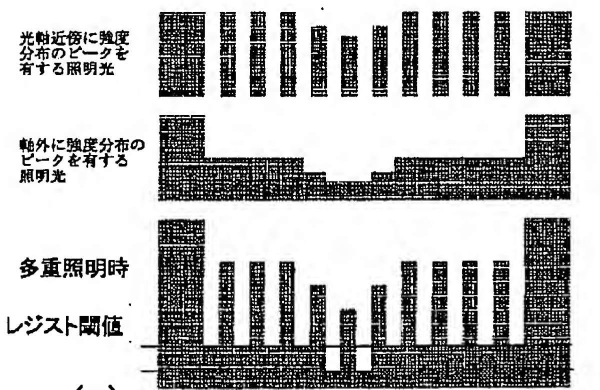


(C)

[Drawing 10]

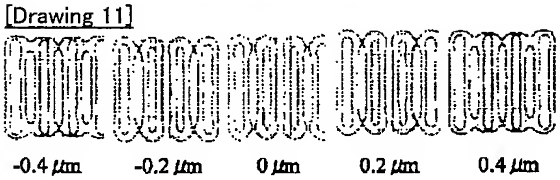


(A) C断面の強度分布

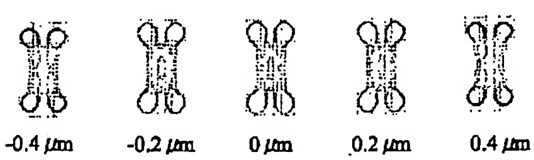


(B) D断面の強度分布

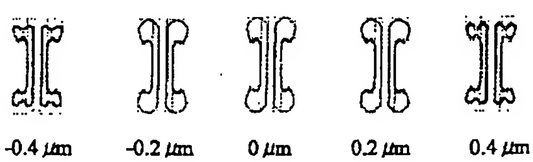
[Drawing 11]



(A)



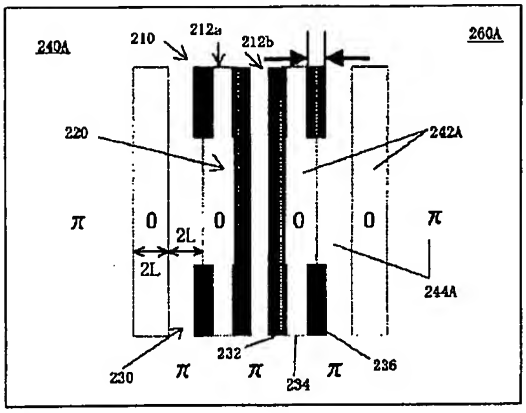
(B)



(C)

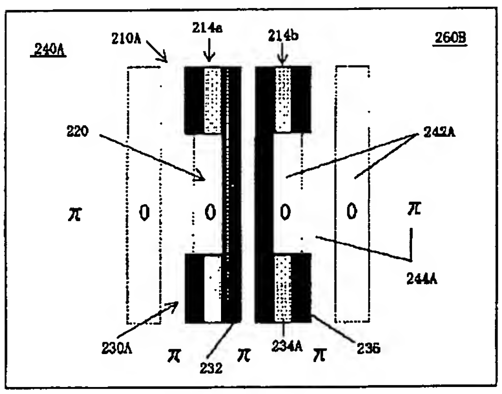
[Drawing 12]

200A

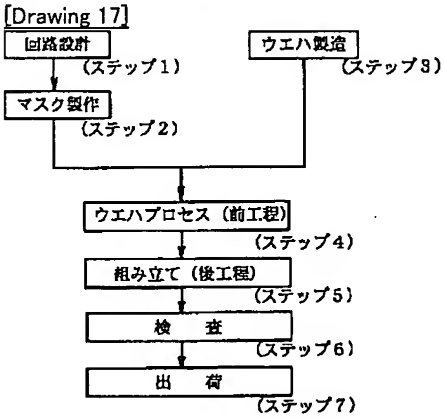


[Drawing 14]

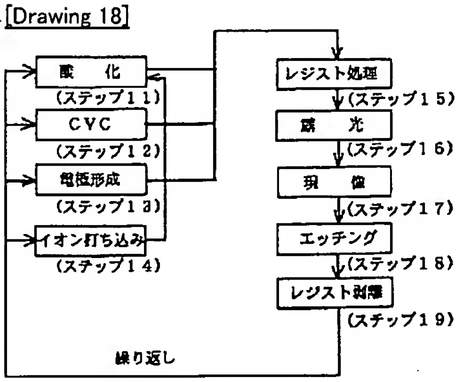
200B



[Drawing 17]



[Drawing 18]



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette]Printing of amendment by regulation of Patent Law Article 17 of 2
[Section Type] The 2nd Type of the part VII gate
[Publication date]Heisei 20(2008) June 19 (2008.6.19)

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[International Patent Classification]

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G03F 1/08 (2006.01)

G03F 7/20 (2006.01)
[FI]

H01L 21/30 528

G03F 1/08 A

G03F 1/08 B

G03F 1/08 D

G03F 7/20 521

H01L 21/30 502 P

H01L 21/30 514 C

H01L 21/30 515 D
[Written Amendment]
[Filing date]Heisei 20(2008) April 23 (2008.4.23)
[Amendment 1]
[Document to be Amended]Description
[Item(s) to be Amended]Claims
[Method of Amendment]Change
[The contents of amendment]
[Claim(s)]
[Claim 1]In an exposure method which exposes a desired pattern to a substrate via a projection optical system by light which illuminated a mask by an illumination-light study system, and passed through said mask,
A pattern of a dummy with periodicity formed so that it might lap with a portion corresponding to a pattern of said request as said mask, A step which forms a phase shift mask which has the pattern which made larger than line width of a pattern of said request a portion with which a portion corresponding to a pattern of said request and a pattern of said dummy lap,
A step which illuminates said phase shift mask using illumination light which has a peak of intensity distribution near the optic axis of said illumination-light study system,
An exposure method having a step which transfers a pattern of said request to said substrate by projecting light which passed through said phase shift mask on a substrate via a projection optical system.
[Claim 2]In an exposure method which exposes a desired pattern to a substrate via a projection optical system by light which illuminated a mask by an illumination-light study system, and passed through said mask,
A pattern of a dummy with periodicity formed so that it might lap with a portion corresponding to a pattern of said request as said mask, A step which forms a phase shift mask which has the pattern which made larger than line width of a pattern of said request a portion with which a portion corresponding to a pattern of said request and a pattern of said dummy lap,
A step which carries out multiplex Lighting Sub-Division of said phase shift mask with an effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division,
An exposure method having a step which transfers a pattern of said request to said substrate by projecting light which passed

through said phase shift mask on a substrate via a projection optical system.

[Claim 3]

A pattern of said request has the 1st pattern part where 1st at least two line aligns at the predetermined intervals, and the 2nd pattern part that has the 2nd line with bigger line width than the 1st line,

In a step which forms said phase shift mask,

The exposure method according to claim 1 forming said phase shift mask by piling up said 1st line of said 1st pattern part with a shade part of a pattern of said dummy.

[Claim 4]

The exposure method according to claim 1 not providing a shade part in a pattern of said dummy.

[Claim 5]

The exposure method according to claim 1 having a light transmission section of half-tone phase shift type into a portion corresponding to a pattern of said request.

[Claim 6]

The exposure method according to claim 1 which illumination light which has a peak of intensity distribution near [said] the optic axis has a circular effective light source, or is characterized by sigma being 0.3 or less.

[Claim 7]

The exposure method according to claim 2 which said small sigma Lighting Sub-Division contains a circular effective light source, or is characterized by sigma being 0.3 or less effective light source.

[Claim 8]

The exposure method according to claim 2, wherein said large sigma Lighting Sub-Division contains an effective light source of a quadrupole, or an effective zona-orbicularis-like light source is included or sigma is [sigma contains a bigger effective light source than 1 or] 0.6 or more effective light sources.

[Claim 9]

In an exposure device which has an illumination-light study system which illuminates a mask, and a projection optical system which carries out projection exposure of the desired pattern to a substrate using light which passed through said mask,

A pattern of a dummy with periodicity formed so that it might lap with a portion corresponding to a pattern of said request as said mask, A phase shift mask which has the pattern which made larger than line width of a pattern of said request a portion with which a portion corresponding to a pattern of said request and a pattern of said dummy lap, Said illumination-light study system illuminates said phase shift mask using illumination light which has a peak of intensity distribution near the optic axis of said illumination-light study system,

An exposure device transferring a pattern of said request to said substrate when said projection optical system projects light which passed through said phase shift mask on a substrate.

[Claim 10]

In an exposure device which has an illumination-light study system which illuminates a mask, and a projection optical system which carries out projection exposure of the desired pattern to a substrate using light which passed through said mask,

A pattern of a dummy with periodicity formed so that it might lap with a portion corresponding to a pattern of said request as said mask, Said illumination-light study system carries out multiplex Lighting Sub-Division of said phase shift mask using a phase shift mask which has the pattern which made larger than line width of a pattern of said request a portion with which a portion corresponding to a pattern of said request and a pattern of said dummy lap, and an effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division,

An exposure device transferring a pattern of said request to said substrate when said projection optical system projects light which passed through said phase shift mask on a substrate.

[Claim 11]

The exposure device according to claim 10 including a diaphragm which has an opening of a fivefold pole so that said effective light source configuration may become a fivefold pole.

[Claim 12]

The exposure device according to claim 17, wherein sigma contains a bigger effective light source than 1, or an effective light source of a quadrupole is included or said large sigma Lighting Sub-Division contains an effective zona-orbicularis-like light source.

[Claim 13]

The exposure device according to claim 10 having a controller which performs either [at least] adjustment of each light exposure of said small sigma Lighting Sub-Division and said large sigma Lighting Sub-Division, or adjustment of a position of a peak of said large sigma Lighting Sub-Division.

[Claim 14]

A step which carries out projection exposure of the substrate using an exposure device given in any 1 clause in given in Claims 9-13,

A device manufacturing method which has a step which develops said said substrate by which projection exposure was carried out.

[Claim 15]

It is a phase shift mask used in order to be illuminated by illumination-light study system and to expose a desired pattern to a substrate,

A phase shift mask comprising:

A pattern of a dummy with periodicity formed so that it might lap with a portion corresponding to a pattern of said request.

A pattern which made larger than line width of a pattern of said request a portion with which a portion corresponding to a pattern of said request and a pattern of said dummy lap.

[Claim 16]

A pattern of said request has the 1st pattern part where 1st at least two line aligns at the predetermined intervals, and the 2nd pattern part that has the 2nd line with bigger line width than the 1st line,

The phase shift mask according to claim 15, wherein a shade part of a pattern of said dummy laps said 1st line of said 1st pattern

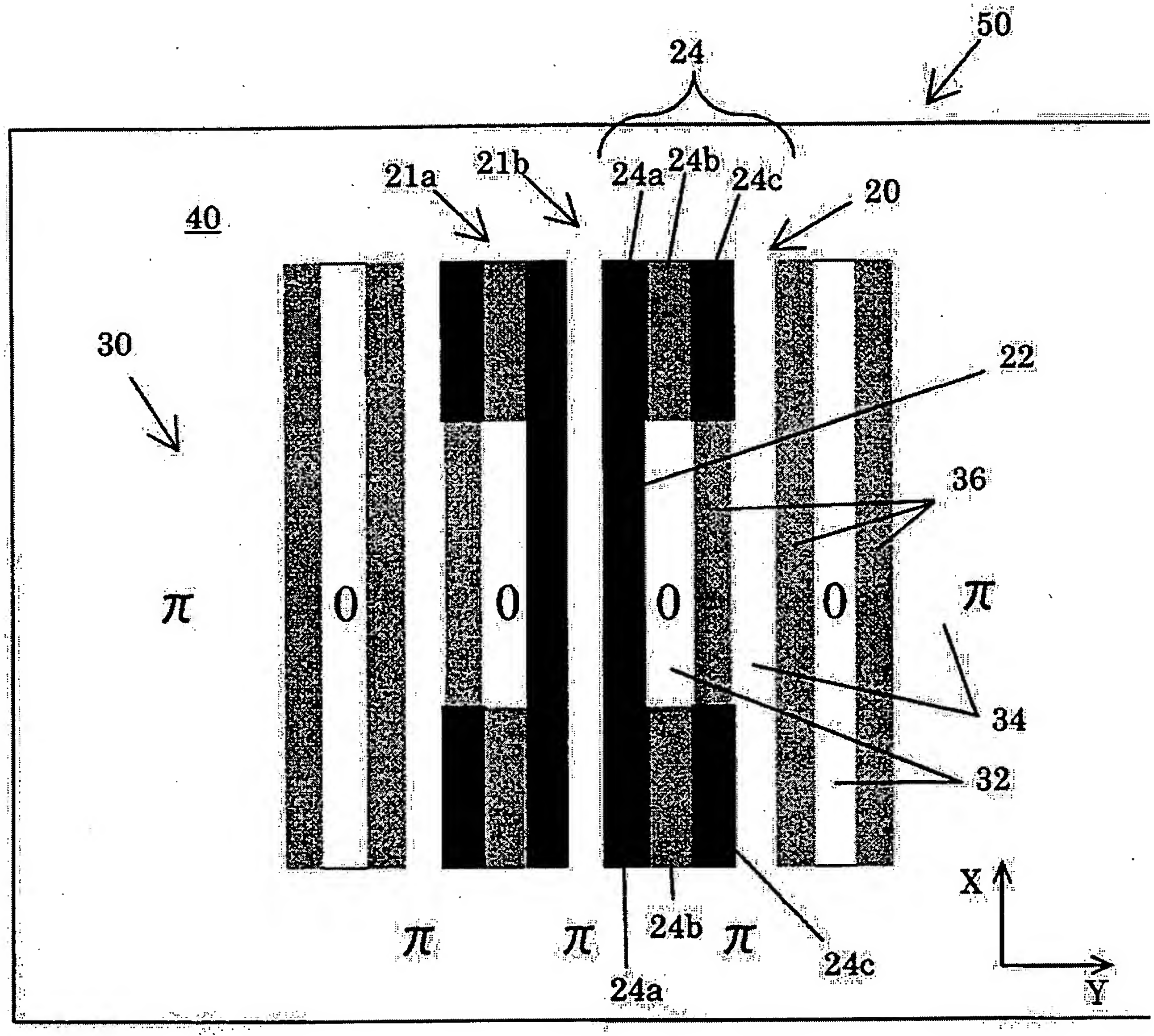
part.
[Claim 17]
The phase shift mask according to claim 15 not providing a shade part in a pattern of said dummy.
[Claim 18]
The phase shift mask according to claim 15 having a light transmission section of half-tone phase shift type into a portion corresponding to a pattern of said request.
[Amendment 2]
[Document to be Amended]Description
[Item(s) to be Amended]0011
[Method of Amendment]Change
[The contents of amendment]
[0011]
Then, it has detailed line width (for example, 0.15 micrometer or less), and the exposure method and equipment with sufficient resolution which can be exposed are provided, without exchanging masks for the mask pattern in which even various patterns or from a L&S pattern to isolation and a complicated pattern are intermingled.
[Amendment 3]
[Document to be Amended]Description
[Item(s) to be Amended]0012
[Method of Amendment]Change
[The contents of amendment]
[0012]
In the exposure method which exposes a desired pattern to a substrate via a projection optical system by the light which the exposure method as a one side face of this invention illuminated the mask by the illumination-light study system, and passed through said mask, The pattern of a dummy with the periodicity formed so that it might lap with the portion corresponding to the pattern of said request as said mask, The step which forms the phase shift mask which has the pattern which made larger than the line width of the pattern of said request the portion with which the portion corresponding to the pattern of said request and the pattern of said dummy lap, By projecting on a substrate the step which illuminates said phase shift mask using the illumination light which has a peak of intensity distribution near the optic axis of said illumination-light study system, and the light which passed through said phase shift mask via a projection optical system, It has a step which transfers the pattern of said request to said substrate.
[Amendment 4]
[Document to be Amended]Description
[Item(s) to be Amended]0013
[Method of Amendment]Change
[The contents of amendment]
[0013]
In the exposure method which exposes a desired pattern to a substrate via a projection optical system by the light which the exposure method as another one side face of this example illuminated the mask by the illumination-light study system, and passed through said mask, The pattern of a dummy with the periodicity formed so that it might lap with the portion corresponding to the pattern of said request as said mask, The step which forms the phase shift mask which has the pattern which made larger than the line width of the pattern of said request the portion with which the portion corresponding to the pattern of said request and the pattern of said dummy lap, It has a step which carries out multiplex Lighting Sub-Division of said phase shift mask with the effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division, and a step which transfers the pattern of said request to said substrate by projecting the light which passed through said phase shift mask on a substrate via a projection optical system.
[Amendment 5]
[Document to be Amended]Description
[Item(s) to be Amended]0014
[Method of Amendment]Deletion
[The contents of amendment]
[Amendment 6]
[Document to be Amended]Description
[Item(s) to be Amended]0015
[Method of Amendment]Deletion
[The contents of amendment]
[Amendment 7]
[Document to be Amended]Description
[Item(s) to be Amended]0016
[Method of Amendment]Deletion
[The contents of amendment]
[Amendment 8]
[Document to be Amended]Description
[Item(s) to be Amended]0017
[Method of Amendment]Deletion
[The contents of amendment]
[Amendment 9]
[Document to be Amended]Description
[Item(s) to be Amended]0018

[Method of Amendment]Deletion
[The contents of amendment]
[Amendment 10]
[Document to be Amended]Description
[Item(s) to be Amended]0019
[Method of Amendment]Change
[The contents of amendment]
[0019]
In the exposure device which has an illumination-light study system in which the exposure device as another side of this invention illuminates a mask, and a projection optical system which carries out projection exposure of the desired pattern to a substrate using the light which passed through said mask, The pattern of a dummy with the periodicity formed so that it might lap with the portion corresponding to the pattern of said request as said mask, The phase shift mask which has the pattern which made larger than the line width of the pattern of said request the portion with which the portion corresponding to the pattern of said request and the pattern of said dummy lap, When said illumination-light study system illuminates said phase shift mask and said projection optical system projects the light which passed through said phase shift mask on a substrate using the illumination light which has a peak of intensity distribution near the optic axis of said illumination-light study system, the pattern of said request is transferred to said substrate.
In the exposure device which has an illumination-light study system in which the exposure device as another side of this invention illuminates a mask, and a projection optical system which carries out projection exposure of the desired pattern to a substrate using the light which passed through said mask, The pattern of a dummy with the periodicity formed so that it might lap with the portion corresponding to the pattern of said request as said mask, The phase shift mask which has the pattern which made larger than the line width of the pattern of said request the portion with which the portion corresponding to the pattern of said request and the pattern of said dummy lap, Using the effective light source equivalent to small sigma Lighting Sub-Division and large sigma Lighting Sub-Division, said illumination-light study system transfers the pattern of said request to said substrate, when multiplex Lighting Sub-Division of said phase shift mask is carried out and said projection optical system projects the light which passed through said phase shift mask on a substrate.
[Amendment 11]
[Document to be Amended]Description
[Item(s) to be Amended]0020
[Method of Amendment]Change
[The contents of amendment]
[0020]
The device manufacturing method as another side of this invention has a step which carries out projection exposure of the substrate using an above-mentioned exposure device, and a step which develops said said substrate by which projection exposure was carried out.
[Amendment 12]
[Document to be Amended]Description
[Item(s) to be Amended]0021
[Method of Amendment]Change
[The contents of amendment]
[0021]
It is a phase shift mask used in order for the phase shift mask as another side of this invention to be illuminated by the illumination-light study system and to expose a desired pattern to a substrate,
It has the pattern which made larger than the line width of the pattern of said request the portion with which the pattern of a dummy with the periodicity formed so that it might lap with the portion corresponding to the pattern of said request, and the portion corresponding to the pattern of said request and the pattern of said dummy lap.
[Amendment 13]
[Document to be Amended]Description
[Item(s) to be Amended]0045
[Method of Amendment]Change
[The contents of amendment]
[0045]
Drawing 3 (E) is an outline top view of the aperture diaphragm 150E which has the zona-orbicularis opening 154 shown in the circular opening 151 shown in drawing 3 (A), and drawing 3 (C). Therefore, the aperture diaphragm 150E also brings about the illumination light by which the illumination light which has a peak of intensity distribution near the optic axis, and the illumination light which has a peak of intensity distribution out of an axis were compounded. The aperture diaphragm 150E has a light transmission section of the transmissivity 1 which consists of the circles 151 and 154, and the shade part 152D of the transmissivity 0.
[Amendment 14]
[Document to be Amended]Description
[Item(s) to be Amended]0046
[Method of Amendment]Change
[The contents of amendment]
[0046]
Various change, such as a part of quadrangle, other polygon, and sector, is possible for the form of the openings 151 and 154. sigma may exceed 1. This modification is explained with reference to drawing 4 and drawing 5. Here, drawing 4 (A) and (B) is an outline top view of the aperture diaphragms 150G and 150H which are the modifications of the aperture diaphragm 150D shown in drawing 3 (D). Drawing 4 (C) is an outline top view of the aperture diaphragm 150I which is a modification of the aperture diaphragm 150E shown in

drawing 3 (E).
[Amendment 15]
[Document to be Amended]Description
[Item(s) to be Amended]0058
[Method of Amendment]Change
[The contents of amendment]
[0058]
The contact part 24 is a rectangle which has the line width 3L respectively in illustration.
Two pairs of contact parts 24 have aligned in parallel via the detailed interval L.
The two contact parts 24 are formed in the both ends of the gate section 22 at each pattern part 21. An object of this invention is to resolve simultaneously the contact part 24 with which line width detailed in this way and interval separated the equal (to L) gate section 22, and the detailed interval L, and large line width (namely, 3L) was located in a line compared with the minimum line width (gate section 22) L. It depends for the suitable line width L for this invention on k_1 shown in the expression 1, and the wavelength lambda of a light source and NA of a projection optical system. For example, when a KrF excimer laser with a wavelength of 248 nm and the projection optical system of NA=0.6 are used, the theoretical resolving R is set to 103 nm from the expression 1 as k_1=0.25, if it is NA=0.85, it will be set to R= 73 nm and this will be set to L.Using an ArF excimer laser with a wavelength of 193 nm, if it is NA=0.85, it will be set to R= 57 nm and this will be set to L. k_1 can change from 0.25 to about 0.5 (or more than it).
[Amendment 16]
[Document to be Amended]Description
[Item(s) to be Amended]0063
[Method of Amendment]Change
[The contents of amendment]
[0063]
Drawing 8 (A) is the light intensity distribution on the plate 400 about a section including A section shown in drawing 6. Drawing 8 (B) is the light intensity distribution on the plate 400 about a section including B section shown in drawing 6. The intensity distribution on the plate 400 can be interpreted as the exposure value distribution of the resist of the plate 400. With reference to drawing 8 (A), about A section, the light intensity of the light transmission section 24b is too high, and it is understood that the contact part 24 is not correctly transferred by the plate 400. It is understood that the dummy pattern 30 remains and the gate section 22 is not correctly transferred by the plate 400 even if it shakes various threshold values of the resist of the plate 400 mentioned later about B section with reference to drawing 8 (B).
[Amendment 17]
[Document to be Amended]Description
[Item(s) to be Amended]0065
[Method of Amendment]Change
[The contents of amendment]
[0065]
Although the pattern 210 is similar to the gate pattern 20, it is different in that the part is made thick.The pattern 210 comprises the pattern parts 212a and 212b (unless it refuses in particular, the reference number 212 summarizes both.) of a couple, and each pattern part 212 comprises the detailed gate section 220 passing through D section, and the two contact parts 230 passing through C section.
[Amendment 18]
[Document to be Amended]Description
[Item(s) to be Amended]0071
[Method of Amendment]Change
[The contents of amendment]
[0071]
As shown in drawing 9 (A), originally, what was L, respectively is large to L1 (>L), and the line width of the gate section 220 and the shade parts 232 and 236 of the contact part 230 is carried out. With reference to drawing 9 (B), about the center lines U1 and U2 of the shade part 246, it is equal, only L2 is thick on the outside, and each of the shade parts 232 and 236 is carried out. As a result, it is understood that L1 is L+2xL2. It is understood that the line width of the field 234 is L-2xL2. Unlike this embodiment, the shade parts 232 and 236 may be made thick by asymmetric width about the center lines U1 and U2, respectively, and as shown in drawing 9 (C), they may be made thick by one side on either side, for example. The line width by which the shade part 232 is made thick may differ from the line width by which the shade part 236 is made thick. The Reason for making the shade parts 232 and 236 thick in this way is for establishing a difference for the pattern 210 about a light exposure from the dummy pattern 240. The ratio of the line width L1 which should be made thick to the line width L is about (for example, about 17%) tens of %, for example.
[Amendment 19]
[Document to be Amended]Description
[Item(s) to be Amended]0074
[Method of Amendment]Change
[The contents of amendment]
[0074]
Drawing 10 (A) is the light intensity distribution on the plate 400 about a section including C section shown in drawing 9 (A). Drawing 10 (B) is the light intensity distribution on the plate 400 about a section including D section shown in drawing 9 (A). The intensity distribution on the plate 400 can be interpreted as the exposure value distribution of the resist of the plate 400. It is understood in drawing 10 (A) that the light intensity of the light transmission section 234 is decreasing rather than the light transmission section 24b about C section as compared with drawing 8 (A). This is because the line width of the light transmission section 234 became

smaller than L (L−2xL2). For this reason, if the threshold value of a resist is shaken suitably, it will be understood that the contact part 230 can transfer on the plate 400. It is understood in drawing 10 (B) that the light intensity of the light transmission section 244 between the gate sections 220 is decreasing rather than the light transmission section 34 between the gate sections 22 about D section as compared with drawing 8 (B). This is because the line width of the light transmission section 244 between the gate sections 220 became smaller than L (L−2xL2). For this reason, if the threshold value of a resist is shaken suitably, it will be understood that the gate section 220 can transfer on the plate 400. As mentioned above, if the threshold value of a resist is shaken suitably, it will be understood that a desired pattern can transfer on the plate 400 correctly.
[Amendment 20]
[Document to be Amended]Description
[Item(s) to be Amended]0075
[Method of Amendment]Change
[The contents of amendment]
[0075]
Next, with reference to drawing 12, the mask 200A as a modification of the mask 200 is explained. Here, drawing 12 is an outline top view of the mask 200A. The mask 200A has the mask pattern 260A which comprises the pattern 210 and the dummy pattern 240A, as shown in the figure.Since the pattern 210 is the same as that of drawing 9, explanation is omitted.
[Amendment 21]
[Document to be Amended]Description
[Item(s) to be Amended]0076
[Method of Amendment]Change
[The contents of amendment]
[0076]
The dummy pattern 240A comprised the light transmission sections 242A and 244A, the phase was set as 0 times and 180 degrees, and both have reversed it 180 degrees. The light transmission sections 242A and 244A had the width 2L in the direction of Y, respectively, and have aligned in parallel [by turns] with the direction of Y. Thus, the dummy patterns 240A of this embodiment differ in the dummy pattern 240 shown in drawing 9, and do not have a shade part. Therefore, it becomes only the pattern 210 to have a shade part which comprises chromium etc. It is possible to distinguish between the light exposure of the pattern 210 and the dummy pattern 240A by such chromium loess composition.
[Amendment 22]
[Document to be Amended]Description
[Item(s) to be Amended]0077
[Method of Amendment]Change
[The contents of amendment]
[0077]
That is, it will be understood that the light exposure of the center section of drawing 8 (A) decreases like the light exposure shown in the center section of drawing 10 (A) since the width of the light transmission section 234 is smaller than the width of the light transmission sections 242A and 244A. Since similarly the width of the light transmission section 244A (and light transmission section 244A sandwiched by the gate section 220 of the couple) sandwiched by two pairs of shade parts 232 is smaller than the width of the light transmission sections 242A and 244A, It will be understood that the light exposure of the center section of drawing 8 (B) decreases like the light exposure shown in the center section of drawing 10 (B). As a result, a desired pattern can be transferred with sufficient contrast on the plate 400.
[Amendment 23]
[Document to be Amended]Description
[Item(s) to be Amended]0078
[Method of Amendment]Change
[The contents of amendment]
[0078]
It will be understood that the same effect is acquired, even if the line width of the boundary part which a phase reverses in the pattern 210 is set up suitably and it controls the light exposure of the desired pattern 210 and the dummy pattern 240 the optimal.
[Amendment 24]
[Document to be Amended]Description
[Item(s) to be Amended]0079
[Method of Amendment]Change
[The contents of amendment]
[0079]
Next, with reference to drawing 14, the mask 200B as a modification of the mask 200 is explained. Here, drawing 14 is an outline top view of the mask 200B. The mask 200B has the mask pattern 260B which comprises the pattern 210A and the dummy pattern 240A, as shown in the figure. Since it is the same as that of drawing 12, the dummy pattern 240A omits explanation.
[Amendment 25]
[Document to be Amended]Description
[Item(s) to be Amended]0080
[Method of Amendment]Change
[The contents of amendment]
[0080]
As shown in drawing 14, the pattern 210A consists of the pattern parts 214a and 214b (unless it refuses in particular, the reference number "214" shall summarize these) of a couple, and each pattern part 214 comprises the gate section 220 and the contact part 230A of a couple. Each contact part 230A has the light transmission section 234A and the shade parts 232 and 236. Since the gate

section 220 and the shade parts 232 and 236 are the same as that of what was mentioned above with reference to drawing 9, explanation is omitted here.
[Amendment 26]
[Document to be Amended]Description
[Item(s) to be Amended]0083
[Method of Amendment]Change
[The contents of amendment]
[0083]
Thus, a desired pattern can be transferred with sufficient contrast on the plate 400 by controlling a part of (between the pattern parts 212 is included) light transmittance of a desired pattern.
[Amendment 27]
[Document to be Amended]Description
[Item(s) to be Amended]0089
[Method of Amendment]Change
[The contents of amendment]
[0089]
The mask pattern 260 in which a part of line width comprised pattern 210 grade made thick and the dummy pattern 240 put on the pattern 210 is formed in the mask 200. The gate section 220 is put on the shade part (dark line part) 236 of the dummy pattern 240, and forms a L&S pattern with the dummy pattern 240, and resolution performance is raised by the phase shift mask. The gate section 220 is made thicker than the dummy pattern 240, and, as for the light transmission section in the meantime, the light exposure is decreasing rather than the dummy pattern 240. Put the contact part 230 on the dummy pattern 240, and in part. (Namely, the field 234) changes to a light transmission section, a part (namely, shade parts 232 and 236) is made thicker than the line width of the dummy pattern 240, and, as a result, in the light transmission section 234, the light exposure is decreasing rather than the dummy pattern 240.
[Amendment 28]
[Document to be Amended]DRAWINGS
[Item(s) to be Amended]Drawing 7
[Method of Amendment]Change
[The contents of amendment]
[Drawing 7]



[Translation done.]

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7/20	５２１	ＨＯ１Ｌ	21/30	５２８	

審査請求　未請求　請求項の数29　ＯＬ　（全 17 頁）　最終頁に続く

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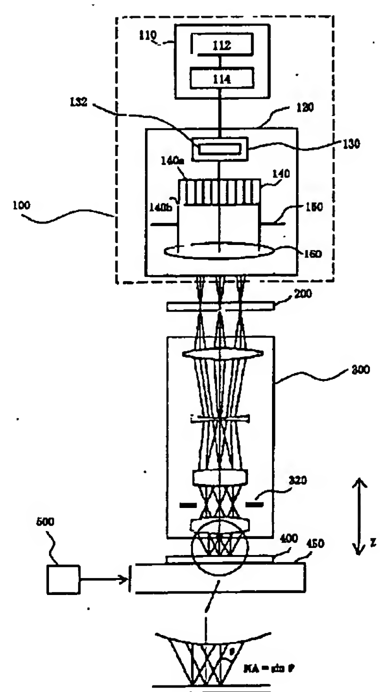
(54)【発明の名称】　露光方法及び装置

(57)【要約】
【課題】　微細な（例えば、０．１５μｍ以下の）線幅を持ち、各種パターンや、Ｌ＆Ｓパターンから孤立及び複雑なパターンまでが混在するマスクパターンを、マスクを交換せずに、解像度良く露光可能な露光方法及び装置を提供する。
【解決手段】　所望のパターンと、当該パターンに重ねられた周期性のあるダミーのパターンとを有する位相シフトマスクを、前記所望のパターンのうち前記ダミーのパターンの効果で解像させるべき部分を前記ダミーのパターンの線幅よりも太くすることによって形成し、光軸近傍に強度分布のピークを有する照明光を利用して前記位相シフトマスクを照明し、前記位相シフトマスクを経た光を被露光面に投影光学系を介して投影することによって、前記所望のパターンを前記被露光面に転写することを特徴とする。



【特許請求の範囲】
【請求項１】 所望のパターンと、当該パターンに重ねられた周期性のあるダミーのパターンとを有する位相シフトマスクを、前記所望のパターンのうち前記ダミーのパターンの効果で解像させるべき部分を前記ダミーのパターンの線幅よりも太くすることによって形成し、
光軸近傍に強度分布のピークを有する照明光を利用して前記位相シフトマスクを照明し、
前記位相シフトマスクを経た光を被露光面に投影光学系を介して投影することによって、前記所望のパターンを前記被露光面に転写することを特徴とする露光方法。
【請求項２】 マスク上のパターンを投影レンズにより被露光面上に露光する露光方法において、
所望のパターン領域及び近傍に微細周期パターンを重ねた位相シフトマスクを用い、照明光として、小σ照明と大σ照明に相当する有効光源により多重照明を行うことを特徴とする露光方法。
【請求項３】 前記所望のパターンは、少なくとも２つの第１の線が所定の間隔で整列する第１のパターン部と、第１の線よりも線幅が大きな第２の線を有する第２のパターン部とを有し、
前記位相シフトマスクを形成するステップは、
前記第１のパターン部の前記第１の線を前記ダミーのパターンの暗線部と重ね、
前記第２のパターン部の前記第２の線を前記ダミーのパターンに重ねることを特徴とする請求項１記載の露光方法。
【請求項４】 前記所望のパターンは、少なくとも２つの第１の線が所定の間隔で整列する第１のパターン部と、第１の線よりも線幅が大きな第２の線を有する第２のパターン部とを有し、
前記所望のパターンの前記一部は前記第１のパターン部の前記第１の線であり、当該第１の線の線幅を前記ダミーのパターンの暗線部の線幅よりも大きくすることを特徴とする請求項１記載の露光方法。
【請求項５】 前記位相シフトマスクを形成するステップは、前記所望のパターンには遮光部を設け、前記ダミーのパターンには遮光部を設けないことを特徴とする請求項１記載の露光方法。
【請求項６】 前記位相シフトマスクを形成するステップは、前記所望のパターンを遮光部とハーフトーン位相シフト形の光透過部として構成することを特徴とする請求項１記載の露光方法。
【請求項７】 前記光軸近傍に強度分布のピークを有する照明光は、円形の有効光源形状を有することを特徴とする請求項１記載の露光方法。
【請求項８】 前記小σ照明は、円形の有効光源形状を有することを特徴とする請求項２記載の露光方法。
【請求項９】 前記光軸近傍に強度分布のピークを有する照明光は、σが０．３以下であることを特徴とする請求項１記載の露光方法。
【請求項１０】 前記小σ照明は、σが０．３以下であることを特徴とする請求項２記載の露光方法。
【請求項１１】 前記大σ照明は、四重極の有効光源形状を有することを特徴とする請求項２記載の露光方法。
【請求項１２】 前記大σ照明は、σが０．６以上であることを特徴とする請求項２記載の露光方法。
【請求項１３】 前記大σ照明は、σが１よりも大きな有効光源形状を有することを特徴とする請求項２記載の露光方法。
【請求項１４】 前記四重極の各照明光は等しいσを有することを特徴とする請求項１１記載の露光方法。
【請求項１５】 前記大σ照明は、輪帯の有効光源形状を有することを特徴とする請求項２記載の露光方法。
【請求項１６】 請求項１乃至１５のうちいずれか一項記載の露光方法を行うことができる露光モードを有することを特徴とする露光装置。
【請求項１７】 マスク、該マスク上のパターンを照明する照明系、及び被露光面上に投影する投影光学系からなる露光装置において、該マスクは所望のパターン領域及び近傍に微細周期パターンを重ねた位相シフトマスクからなり、照明系は小σ照明と大σ照明に相当する多重有効光源を有し、これら小σ照明と大σ照明の組み合わされた多重照明系を有することを特徴とする露光装置。
【請求項１８】 前記多重有効光源形状が五重極になるように五重極の開口を有する絞りを含むことを特徴とする請求項１７記載の露光装置。
【請求項１９】 前記大σ照明はσが１よりも大きな有効光源形状を有することを特徴とする請求項１７記載の露光装置。
【請求項２０】 前記大σ照明は四重極の有効光源形状を有し、前記四重極の各照明光のσは等しいことを特徴とする請求項１７記載の露光装置。
【請求項２１】 前記大σ照明は輪帯の有効光源形状を形成し、前記小σ照明は前記輪帯の内側に設けられた円形の有効光源形状を形成することを特徴とする請求項１７記載の露光装置。
【請求項２２】 前記照明装置は、前記小σ照明と前記大σ照明のそれぞれの露光量を調整する機能及び／又は前記大σ照明のピークの位置を調整する機能を有する装置を有することを特徴とする請求項１７記載の露光装置。
【請求項２３】 請求項１６乃至２２記載のうちいずれか一項記載の露光装置を用いて被処理体を投影露光するステップと、
前記投影露光された前記被処理体に所定のプロセスを行うステップとを有するデバイス製造方法。
【請求項２４】 請求項１６乃至２２記載のうちいずれか一項記載の露光装置を用いて投影露光された前記被処理体より製造されるデバイス。

【請求項25】　所望のパターンと、当該パターンに重ねられた周期性のあるダミーのパターンとを有し、前記所望のパターンのうち前記ダミーのパターンの効果で解像されるべき部分が前記ダミーのパターンの線幅よりも太くされていることを特徴とする位相シフトマスク。

【請求項26】　前記所望のパターンは、少なくとも2つの第1の線が所定の間隔で整列する第1のパターン部と、第1の線よりも線幅が大きな第2の線を有する第2のパターン部とを有し、

前記所望のパターンの前記一部は前記第1のパターン部の前記第1の線であり、当該第1の線の線幅は前記ダミーのパターンの暗線部の線幅よりも大きいことを特徴とする請求項25記載のマスク。

【請求項27】　前記所望のパターンには遮光部を設け、前記ダミーのパターンには遮光部を設けないことを特徴とする請求項25記載のマスク。

【請求項28】　前記位相シフトマスクの前記所望のパターンは遮光部と、ハーフトーン位相シフト形の光透過部から構成されることを特徴とする請求項25記載のマスク。

【請求項29】　マスクに所望のパターンを形成し、当該パターンに周期性のあるダミーのパターンを重ね合わせ、

前記所望のパターンの一部を前記ダミーのパターンよりも太くすることによって前記マスクを位相シフトマスクとして製造する前記マスクの製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、一般には、露光に関し、特に、IC、LSIなどの半導体チップ、液晶パネルなどの表示素子、磁気ヘッドなどの検出素子、CCDなどの撮像素子といった各種デバイス、マイクロメカニクスで用いる広域なパターンの製造に用いられる露光装置及び方法、デバイス製造方法、及び、前記被処理体から製造されるデバイスに関する。ここで、マイクロメカニクスは半導体集積回路製造技術を微細構造体の製作に応用し、ミクロン単位の高度な機能を持った機械システムを作る技術をいう。

【0002】

【従来の技術】フォトリソグラフィ工程は、マスクパターンをシリコンウェハ、ガラスプレート等（以下、単に「ウェハ」という。）に塗布した感光性物質（レジスト）に露光装置を使用して転写する工程であり、レジスト塗布、露光、現像、エッチング、レジスト除去の工程を含む。このうち露光では、解像度、重ね合わせ精度、スループットの3つのパラメータが重要である。解像度は正確に転写できる最小寸法、重ね合わせ精度はウェハにパターンを幾つか重ね合わせる際の精度、スループットは単位時間当たり処理される枚数である。

【0003】フォトリソグラフィ技術を用いてデバイスを製造する際に、マスク又はレチクル（本出願ではこれらの用語を交換可能に使用する）に描画されたパターンを投影光学系によってウェハに投影してパターンを転写する投影露光装置が従来から使用されている。投影光学系はパターンからの回折光をウェハ上に干渉及び結像させ、通常の露光ではパターンからの0次及び±1次の回折光（即ち、三光束）を干渉させる。

【0004】マスクパターンは、近接した周期的なラインアンドスペース（L&S）パターン、近接及び周期的なコンタクトホールパターン、近接せずに孤立した孤立パターンを含むが、高解像度でパターンを転写するためには、パターンの種類に応じて最適な露光条件（照明条件や露光量など）を選択する必要がある。

【0005】投影露光装置の解像度Rは、光源の波長λと投影光学系の開口数（NA）を用いて以下のレーリーの式で与えられる。

【0006】

【数1】

$$R=k_1(\lambda/NA)$$

【0007】ここで、k_1は現像プロセスなどによって定まる定数であり、通常露光の場合にはk_1は約0.5～0.7である。

【0008】近年のデバイスの高集積化に対応して、転写されるパターンの微細化、即ち、高解像度化が益々要求されている。高解像力を得るには、上式から開口数NAを大きくすること、及び、波長λを小さくすることが有効であるが、これらの改善は現段階では限界に達しており、通常露光の場合にウェハに0.15μm以下のパターンを形成することは困難である。そこで、パターンを経た回折光の中で二光束を干渉及び結像させる位相シフトマスク技術が従来から提案されている。位相シフトマスクは、マスクの隣接する光透過部分の位相を180°反転することによって0次回折光を相殺し、2つの±1次回折光を干渉させて結像するものである。かかる技術によれば、上式のk_1を実質的に0.25にするできるので、解像度Rを改善してウェハに0.15μm以下のパターンを形成することができる。

【0009】

【発明が解決しようとする課題】しかし、従来の位相シフトマスク技術は、周期的なL&Sパターンのような単純なパターンには効果的であるが、孤立パターンや任意の複雑なパターンを露光性能（即ち、解像度、重ね合わせ精度及びスループット）良く露光することは困難であった。特に、近年の半導体産業は、より高付加価値な、多種多様なパターンが混在するシステムチップに生産が移行しつつあり、マスクにも複数種類のパターンを混在させる必要が生じてきている。

【0010】これに対して、公開特許平成11年第143085号公報にあるように、2枚のマスクを用いて異

なる種類のパターンを別々に露光する二重露光（又は多重露光）を使用することが考えられるが、従来の二重露光は、2枚のマスクを必要とするのでコストアップを招き、2回の露光のためにスループットが低下し、2回の露光の高い重ね合わせ精度を必要とするため実用上解決すべき問題が多い。

【0011】そこで、微細な（例えば、0．15μm以下の）線幅を持ち、各種パターンやL＆Sパターンから孤立及び複雑なパターンまでが混在するマスクパターンを、マスクを交換せずに、解像度良く露光可能な露光方法及び装置を提供することを本発明の例示的目的とする。

【0012】

【課題を解決するための手段】上記目的を達成するために、本発明の一側面としての露光方法は、所望のパターンと、当該パターンに重ねられた周期性のあるダミーのパターンとを有する位相シフトマスクを、前記所望のパターンのうち前記ダミーパターンの効果で解像させるべき部分を前記ダミーパターンの線幅より太くすることによって形成し、光軸近傍に強度分布のピークを有する照明光により前記位相シフトマスクを照明し、前記位相シフトマスクを経た光を被露光面に投影光学系を介して投影することによって、前記所望のパターンを前記被露光面に転写することを特徴とする。

【0013】また、本発明の別の側面としての露光方法は、マスク上のパターンを投影レンズにより被露光面上に露光する露光方法において、所望のパターン領域及び近傍に微細周期パターンを重ねた位相シフトマスクを用い、照明光として、小σ照明と大σ照明に相当する有効光源により多重照明を行うことを特徴とする。

【0014】光軸近傍に強度分布のピークを有する照明光（又は小σ照明）は、例えば、有効光源形状が円形でσが0．3以下であり、0次回折光と±1次回折光の干渉をもたらす。前者の露光方法は、このように、光軸近傍に強度分布のピークを有する照明光のみでその効果を発揮する。

【0015】大σ照明は、例えば、有効光源形状が輪帯又は四重極でσが0．6以上であり、0次回折光と＋1次又は－1次回折光からなる二光束の干渉をもたらす。これらの照明は、（投影光学系の瞳面と共役な位置に配置されて）前記有効光源形状を開口として有する絞りにより達成することができる。

【0016】上述の露光方法は、（1）所望のパターンの一部を太らせることによってダミーのパターンと露光量との差を設け、（2）光軸近傍のピークの部分の照明光により前記周期性のあるパターンを露光し、（3）前記ピークの部分の外側の部分の照明光により前記所望のパターンを露光し、（4）被露光面の（レジストの）閾値を適当に選択することによって所望のパターンを被露光面に形成する。

【0017】前記所望のパターンは、少なくとも2つの第1の線が所定の間隔で整列する第1のパターン部と、第1の線よりも線幅が大きな第2の線を有する第2のパターン部とを有し、前記第1のパターン部の前記第1の線を前記ダミーのパターンの暗線部と重ね、前記第2のパターン部の前記第2の線を前記ダミーのパターンに重ねてもよい。微細な第1の線及びその近傍を周期構造にすることによって解像性能を向上させることができる。前記所望のパターンの前記一部は前記第1のパターン部の前記第1の線であり、当該第1の線の線幅を前記ダミーのパターンの暗線部の線幅よりも大きくしてもよい。所望のパターンの微細部分を少し太らせることによりダミーのパターンとの露光量に差をつけて強調することができる。

【0018】前記所望のパターンには遮光部を設け、前記ダミーのパターンには遮光部を設けなくてもよい。所望のパターンとダミーにパターンの露光量に差をつけることができるのでコントラストの高いパターンを形成することができる。前記所望のパターンを遮光部とハーフトーン位相シフト形の光透過部として構成してもよい。かかる構成によっても所望のパターンをダミーのパターンとの露光量に差をつけて強調することができる。

【0019】本発明の一側面としての露光装置は、上述の露光方法を行う露光モードを有することを特徴とする。また、本発明の別の側面としての露光装置は、マスク、該マスク上のパターンを照明する照明系、及び被露光面上に投影する投影光学系からなる露光装置において、該マスクは所望のパターン領域及び近傍に微細周期パターンを重ねた位相シフトマスクからなり、照明系は小σ照明と大σ照明に相当する多重有効光源を有し、これら小σ照明と大σ照明の組み合わされた多重照明系を有することを特徴とする。これらの露光装置も上述の露光方法の作用を奏することができる。

【0020】本発明の更に別の側面としてのデバイス製造方法は、上述の露光装置を用いて前記被処理体を投影露光するステップと、前記投影露光された前記被処理体に所定のプロセスを行うステップとを有する。上述の露光装置の作用と同様の作用を奏するデバイス製造方法の請求項は、中間及び最終結果物であるデバイス自体にもその効力が及ぶ。また、かかるデバイスは、例えば、ＬＳＩやＶＬＳＩなどの半導体チップ、ＣＣＤ、ＬＣＤ、磁気センサ、薄膜磁気ヘッドなどを含む。

【0021】本発明の別の側面としてのマスク製造方法は、マスクに所望のパターンを形成し、当該パターンに周期性のあるダミーのパターンを重ね合わせ、前記所望のパターンの一部を前記ダミーのパターンよりも太くすることによって前記マスクを位相シフトマスクとして製造することを特徴とする。本方法によって製造されたマスクは上述の作用を奏する。

【0022】本発明の更なる目的又はその他の特徴は、

以下添付図面を参照して説明される好ましい実施例によって明らかにされるであろう。

【0023】

【発明の実施の形態】以下、添付図面を参照して本発明の例示的な露光装置について説明する。ここで、図1は、本発明の露光装置1の概略ブロック図である。図1に示すように、露光装置1は、照明装置100と、マスク200と、投影光学系300と、プレート400と、ステージ450と、結像位置調節装置500とを有する。

【0024】本実施形態の露光装置1は、ステップアンドスキャン方式でマスク200に形成された回路パターンをプレート400に露光する投影露光装置であるが、本発明はステップアンドリピート方式その他の露光方式を適用することができる。ここで、ステップアンドスキャン方式は、マスクに対してウェハを連続的にスキャンしてマスクパターンをウェハに露光すると共に、1ショットの露光終了後ウェハをステップ移動して、次のショットの露光領域に移動する露光法である。また、ステップアンドリピート方式は、ウェハのショットの一括露光ごとにウェハをステップ移動して次のショットを露光領域に移動する露光法である。

【0025】照明装置100は転写用の回路パターンが形成されたマスク200を照明し、光源部110と照明光学系120とを有する。

【0026】光源部110は、光源としてのレーザー112と、ビーム整形系114とを含む。

【0027】レーザー112は、波長約193nmのArFエキシマレーザー、波長約248nmのKrFエキシマレーザー、波長約157nmのF_2エキシマレーザーなどのパルスレーザーからの光を使用することができる。レーザーの種類はエキシマレーザーに限定されず、例えば、YAGレーザーを使用してもよいし、そのレーザーの個数も限定されない。例えば、独立に動作する2個の固体レーザーを使用すれば固体レーザー相互間のコヒーレンスはなく、コヒーレンスに起因するスペックルはかなり低減する。さらにスペックルを低減するために光学系を直線的又は回転的に揺動させてもよい。また、光源部110に使用可能な光源はレーザー112に限定されるものではなく、一又は複数の水銀ランプやキセノンランプなどのランプも使用可能である。

【0028】ビーム整形系114は、例えば、複数のシリンドリカルレンズを備えるビームエクスパンダ等を使用することができ、レーザー112からの平行光の断面形状の寸法の縦横比率を所望の値に変換する（例えば、断面形状を長方形から正方形にするなど）ことによりビーム形状を所望のものに成形する。ビーム成形系114は、後述するオプティカルインテグレータ140を照明するのに必要な大きさと発散角を持つ光束を形成する。

【0029】また、図1には示されていないが、光源部110は、コヒーレントなレーザー光束をインコヒーレント化するインコヒーレント化光学系を使用することが好ましい。インコヒーレント化光学系は、例えば、公開特許平成3年第215930号公報の図1に開示されているような、入射光束を光分割面で少なくとも2つの光束（例えば、p偏光とs偏光）に分岐した後で一方の光束を光学部材を介して他方の光束に対してレーザー光のコヒーレンス長以上の光路長差を与えてから分割面に再誘導して他方の光束と重ね合わせて射出されるようにした折り返し系を少なくとも一つ備える光学系を用いることができる。

【0030】照明光学系120は、マスク200を照明する光学系であり、本実施形態では、集光光学系130と、オプティカルインテグレータ140と、開口絞り150と、コンデンサーレンズ160とを含む。照明光学系120は、軸上光、軸外光を問わず使用することができる。なお、本実施形態の照明光学系120は、プレート400上の転写領域の寸法を変更するためのマスキングブレードやスキャンブレードを有してもよい。本実施形態の照明光学系120は、複数のレンズ及び必要なミラーを有し、射出側でテレセントリックとなるアフォーカル系を構成している。

【0031】集光光学系130は、まず、必要な折り曲げミラーやレンズ等を含み、それを通過した光束をオプティカルインテグレータ140に効率よく導入する。例えば、集光光学系130は、ビーム成形系114の出射面と後述するハエの目レンズとして構成されたオプティカルインテグレータ140の入射面とが光学的に物体面と瞳面（又は瞳面と像面）の関係（かかる関係を本出願ではフーリエ変換の関係と呼ぶ場合がある）になるように配置されたコンデンサーレンズを含み、それを通過した光束の主光線をオプティカルインテグレータ140の中心及び周辺のどのレンズ素子142に対しても平行に維持する。

【0032】集光光学系130は、マスク200への照明光の露光量を照明毎に変更可能な露光量調整部132を更に含む。露光量調整部132は、アフォーカル系の各倍率を変えることにより入射光束のビーム断面形状を変化させることができる。代替的に、露光量調整部132はズームレンズ等からなり、レンズを光軸方向に移動させ角倍率を変えられるようにしてもよい。必要があれば、露光量調整部132は、入射光束をハーフミラーにより分割してセンサにより光量を検出してかかる検出結果に基づいてレーザー112の出力及び／又は光学系の一部を調整することができる。露光量調整部132は、光学素子（例えば、光量調整（ND）フィルター）を入れ替えたり、及び／又は、ズームレンズにより結像倍率を変えたりすることにより、後述する開口絞り150の中央部と周辺部との光量比を調整することもできる。後述するように、露光量調節部132は、前記所望のパタ

ーン及び／又は前記プレート４００において求められるコントラストに基づいて、露光量を調節することができる。例えば、パターン形状を重視するものであれば光軸にピークを有する照明光の露光量の比を相対的に大きくすればよいし、コントラストを重視するものであれば軸外に強度分布のピークを有する照明光の露光量の比を相対的に大きくすればよい。本実施形態の露光量調整部１３２は、軸外に強度分布を有する照明光（大σ照明）の前記ピーク位置を調節する機能も有する。

【００３３】例えば、露光調整部１３２は、図２に示すような中央部が周辺部よりも光強度の高い照明光を作成することによって、後述する開口絞り１５０が図３（Ｆ）に示すような円形開口絞り１５０Ｆを使用することを可能にする。ここで、図２は中央部が周辺部よりも光強度の高い照明光の光強度分布である。図３（Ｆ）は円形開口絞り１５０Ｆの概略平面図である。なお、本出願では、「光軸近傍に強度分布のピークを有する照明光を利用した照明光」は図２に示すような照明光を含むものとする。開口絞り１５０Ｆは、透過率１の円形光透過部１５５と透過率０の輪帯状の遮光部１５２Ｆから構成される。

【００３４】オプティカルインテグレータ１４０はマスク２００に照明される照明光を均一化し、本実施形態では、入射光の角度分布を位置分布に変換して出射するハエの目レンズとして構成される。ハエの目レンズは、その入射面１４０ａと出射面１４０ｂとがフーリエ変換の関係に維持されている。但し、後述するように、本発明が使用可能なオプティカルインテグレータ１４０はハエの目レンズに限定されるものではない。

【００３５】ハエの目レンズ１４０は互いの焦点位置がそれと異なるもう一方の面にあるレンズ（レンズ素子）１４２を複数個並べたものである。また、ハエの目レンズを構成する各レンズ素子の断面形状は、各レンズ素子のレンズ面が球面である場合、照明装置の照明領域と略相似である方が照明光の利用効率が高い。これは、ハエの目レンズの光入射面と照明領域が物体と像との関係（共役関係）であるからである。

【００３６】ハエの目レンズは、本実施形態ではマスク２００の形状に合わせて正方形断面のレンズ素子を多数組み合わせて構成されているが、本発明は、断面円形、長方形、六角形その他の断面形状を有するレンズ素子を排除するものではない。ハエの目レンズの出射面１４０ｂ又はその近傍に形成された複数の点光源（有効光源）からの各光束をコンデンサーレンズ１６０によりマスク２００に重畳している。これにより、多数の点光源（有効光源）によりマスク２００全体が均一に照明される。

【００３７】本発明で適用可能なオプティカルインテグレータ１４０はハエの目レンズに限定されず、例えば、図１６に示すオプティカルインテグレータ１４０Ａに置換されてもよい。ここで、図１６は、オプティカルインテグレータ１４０Ａの拡大斜視図である。オプティカルインテグレータ１４０Ａは２組のシリンドリカルレンズアレイ（又はレンチキュラーレンズ）板１４４及び１４６を重ねることによって構成される。１枚目と４枚目の組のシリンドリカルレンズアレイ板１４４ａ及び１４４ｂはそれぞれ焦点距離ｆ１を有し、２枚目と３枚目の組のシリンドリカルレンズアレイ板１４６ａ及び１４６ｂはｆ１とは異なる焦点距離ｆ２を有する。同一組のシリンドリカルレンズアレイ板は相手の焦点位置に配置される。２組のシリンドリカルレンズアレイ板１４４及び１４６は直角に配置され、直交方向でＦナンバー（即ち、レンズの焦点距離／有効口径）の異なる光束を作る。なお、オプティカルインテグレータ１４０Ａの組数が２に限定されないことはいうまでもない。

【００３８】ハエの目レンズ１４０は光学ロッドに置換される場合もある。光学ロッドは、入射面で不均一であった照度分布を出射面で均一にし、ロッド軸と垂直な断面形状が照明領域とほぼ同一な縦横比を有する矩形断面を有する。なお、光学ロッドはロッド軸と垂直な断面形状にパワーがあると出射面での照度が均一にならないので、そのロッド軸に垂直な断面形状は直線のみで形成される多角形である。その他、ハエの目レンズ１３０は、拡散作用をもった回折素子に置換されてもよい。

【００３９】オプティカルインテグレータ１４０の出射面１４０ｂの直後には、形状及び径が固定された開口絞り１５０が設けられている。本実施形態の開口絞り１５０は、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光を利用して（即ち、これらを順次投射するか合成した状態で投射することによって）マスク２００を照明するための開口形状を有する。このように、本発明は、光軸近傍に強度分布のピークを有する照明光をもたらす開口絞りと、軸外に強度分布のピークを有する照明光をもたらす開口絞りを用意して、そのうちの一方を先にマスク２００に投射して、その後、他方をマスク２００に投射する場合も含む。本発明の特徴の一つはマスク２００の交換に伴う諸問題を解決することであり、マスク２００が交換されない限り、開口絞り１５０の交換は問題ではないからである。開口絞り１５０は投影光学系３００の瞳面３２０と共役な位置に設けられており、開口絞りの１５０の開口形状は投影光学系３００の瞳面３２０の有効光源形状に相当する。

【００４０】光軸近傍に強度分布のピークを有する照明光はσが０．３以下であり、０次回折光と±１次回折光の干渉をもたらす。また、軸外に強度分布のピークを有する照明光はσが０．６以上であり、０次回折光と＋１次又は－１次回折光からなる二光束の干渉をもたらす。ここで、σは投影光学系３００のマスク２００側の開口数（ＮＡ）に対する照明光学系１２０のマスク２００側のＮＡである。光軸近傍に強度分布のピークを有する照

明は、小σ照明、通常の照明などと呼ばれる場合もある。軸外に強度分布のピークを有する照明は、大σ照明、斜入射照明、変形照明などと呼ばれる場合もある。

【0041】図3乃至図6を参照して、開口絞り150に適用可能な例示的な形状を説明する。ここで、図3乃至図6は、開口絞り150の例示的形状の概略平面図である。図3（A）は、光軸近傍に強度分布のピークを有する照明光をもたらすための、比較的半径の小さな円形開口151を有する開口絞り150Aの概略平面図である。開口絞り150Aは、円151から構成される透過率1の光透過部と遮光部152Aとを有する。

【0042】図3（B）は、軸外に強度分布のピークを有する照明光をもたらすための、四重極の円153からなる透過率1の光透過部と遮光部152Bとを有する開口絞り150Bの概略平面図である。円形開口153は、中心位置がσ＝1以下の照明光をもたらし、それぞれ、±45度と±135度に配置されている。好ましくは、各円153がもたらす照明光のσは等しい。

【0043】図3（C）は、軸外に強度分布のピークを有する照明光をもたらすための、輪帯開口154からなる透過率1の光透過部と遮光部152Cとを有する開口絞り150Cの概略平面図である。

【0044】図3（D）は、図3（A）に示す円形開口151と図3（B）に示す円形開口153とを有する5重極照明用絞りとして構成された開口絞り150Dの概略平面図である。開口絞り150Dは、従って、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とが合成された照明光をもたらす。開口絞り150Dの円151及び153は同一の大きさを有する。開口絞り150Dは、円151及び153からなる透過率1の光透過部と、透過率0の遮光部152Dとを有する。

【0045】図3（E）は、図3（A）に示す円形開口151と図3（C）に示す輪帯開口153とを有する開口絞り150Eの概略平面図である。従って、開口絞り150Eも、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とが合成された照明光をもたらす。開口絞り150Eは、円151及び154からなる透過率1の光透過部と、透過率0の遮光部152Dとを有する。

【0046】また、開口151及び153の形状は、四角形その他の多角形、扇形の一部など種々の変更が可能である。また、σが1を超えてもよい。かかる変形例を図4及び図5を参照して説明する。ここで、図4（A）及び（B）は図3（D）に示す開口絞り150Dの変形例である開口絞り150G及び150Hの概略平面図である。図4（C）は図3（E）に示す開口絞り150Eの変形例である開口絞り150Iの概略平面図である。

【0047】開口絞り150Gは、円形開口151よりも幾分大きな円形開口151Aとσσが1を部分的に超えた矩形開口153Aからなる透過率1の光透過部と、透過率0の遮光部152Gとを有する。本発明者はσが1を部分的に超えた照明光を利用するとプレート400に形成されるパターン像が明確になることを発見した。開口絞り150Hは、開口絞り150Cは、σが1以下の円形開口151と扇形開口153Bからなる透過率1の光透過部と、透過率0の遮光部152Hとを有する。扇形開口153Bの寸法は任意に調節することができる。開口絞り150Iは、円形開口151とσ＝1を部分的に超えた輪帯（又は矩形帯）154Aからなる透過率1の光透過部と、透過率0の遮光部152Iとを有する。開口絞り150G乃至Iの機能は上述の開口絞り150D等と同一であるので、ここでは詳しい説明は省略する。

【0048】図5に、開口絞り150に適用可能な別の変形例としての九重極照明用絞りとして構成された開口絞り150Jの概略平面図を示す。開口絞り150Jは、円形開口151よりも幾分大きな円形開口151Bと、開口位置のσが1以下の円形開口153Cと、σが1を部分的に超えて円形開口151Bと同一の大きさを有する円形開口153Dからなる透過率1の光透過部と、透過率0の遮光部152Jとを有する。円形開口153Cは、0度、90度、180度及び270度の位置に、円形開口153Dは、±45度及び±135度の位置に設けられている。開口絞り150Jの機能も上述の開口絞り150D等と同一であるので、ここでは詳しい説明は省略する。

【0049】複数種類の開口絞り150の中から所望の開口絞り150を選択するためには、開口絞り150A乃至150Jを、例えば、図示しない円盤状ターレットに配置して切り替えの際にターレットを回転させればよい。これにより、照明装置120は、まず、光軸にピークを有する照明光及び軸外に強度分布のピークを有する照明光のうちの一方によりマスク200を照明し、その後、他方によりマスク200を照明することができる。また、光軸にピークを有する照明光と軸外に強度分布のピークを有する照明光とが合成された照明光において、上述の露光量調整部132は、それぞれの露光量比を変化させることができる。

【0050】コンデンサーレンズ160はハエの目レンズ140から出た光をできるだけ多く集めて主光線が平行、すなわちテレセントリックになるようにマスク200をケーラー照明する。マスク200とハエの目レンズ140の出射面140bとはフーリエ変換の関係に配置されている。

【0051】露光装置1は、必要があれば、照度ムラ制御用の幅可変スリットや走査中の露光領域制限用のマスキングブレード（絞り又はスリット）等を有する。マスキングブレードが設けられる場合には　マスキングブレードとハエの目レンズ140の出射面140bとはフー

リエ変換の関係に配置され、マスク２００面と工学的に略共役な位置に設けられる。マスキングブレードの開口部を透過した光束をマスク２００の照明光として使用する。マスキングブレードは開口幅を自動可変できる絞りであり、後述するプレート４００の（開口スリットの）転写領域を縦方向で変更可能にする。また、露光装置は、プレート４００の（１ショットのスキャン露光領域としての）転写領域の横方向を変更可能にする、上述のマスキングブレードと類似した構造のスキャンブレードを更に有してもよい。スキャンブレードも開口幅が自動可変できる絞りであり、マスク２００面と光学的にほぼ共役な位置に設けられる。これにより露光装置１は、これら二つの可変ブレードを用いることによって露光を行うショットの寸法に合わせて転写領域の寸法を設定することができる。

【００５２】マスク２００は、例えば、石英製で、その上には転写されるべき回路パターン（又は像）が形成され、図示しないマスクステージに支持及び駆動される。マスク２００から発せられた回折光は投影光学系３００を通りプレート４００上に投影される。プレート４００は、被処理体でありレジストが塗布されている。マスク２００とプレート４００とは光学的に共役の関係に配置される。本実施形態の露光装置１はステップアンドスキャン方式の露光装置（即ち、スキャナー）であるため、マスク２００とプレート４００を走査することによりマスク２００のパターンをプレート４００上に転写する。なお、ステップアンドリピート方式の露光装置（即ち、「ステッパー」）であれば、マスク２００とプレート４００とを静止させた状態で露光を行う。

【００５３】マスクステージは、マスク２００を支持して図示しない移動機構に接続されている。マスクステージ及び投影光学系３００は、例えば、床等に載置されたベースフレームにダンパ等を介して支持されるステージ鏡筒定盤上に設けられる。マスクステージは、当業界周知のいかなる構成をも適用できる。図示しない移動機構はリニアモータなどで構成され、ＸＹ方向にマスクステージを駆動することでマスク２００を移動することができる。露光装置１は、マスク２００とプレート４００を図示しない制御機構によって同期した状態で走査する。

【００５４】本発明の一側面としてのマスク２００は、所望のパターンと、当該パターンに重ねられた周期性のあるダミーのパターンとを有し、所望のパターンのうちダミーのパターンの効果で解像させるべき部分は前記ダミーのパターンの線幅よりも太くされた位相シフトマスクとして形成されている。当該マスクは、例えば、所望のパターンを形成し、当該パターンに周期性のあるダミーのパターンを重ね合わせ、前記所望のパターンの一部を前記ダミーのパターンよりも太くすることによって位相シフトマスクとして製造される。後述するように、所望のパターンの一部が太くされるのはダミーのパターンとの露光量に差を設けるためである。

【００５５】本発明のマスク２００のパターン構成を説明するために、まず、所望のパターンを説明する。ここで、所望のパターンを、例えば、図６に示すようなゲートパターン２０とする。ここで、図６は、所望のパターン２０の概略平面図である。

【００５６】ゲートパターン２０は、一対のパターン部２１ａ及び２１ｂ（特に断らない限り、参照番号２１は両者を総括する。）から構成され、各パターン部２１は、Ｂ断面を通る微細なゲート部２２と、Ａ断面を通る２つのコンタクト部２４とから構成される。ゲートパターン２０は、例えば、クロムなどによって構成される。

【００５７】図６に示すように、両ゲート部２２は、それぞれ微細な線幅Ｌを有する長方形であり、微細な間隔Ｌで平行に整列している。換言すれば、ゲート部２２はＬ＆Ｓパターンを部分的に構成している。本実施形態ではＬは０．１２μｍである。

【００５８】コンタクト部２４は、それぞれ例示的に線幅３Ｌを有する長方形であり、二対のコンタクト部２４は微細な間隔Ｌを介して平行に整列している。また、各パターン部２１には２つのコンタクト部２４がゲート部２２の両端に設けられている。本発明は、このように微細な線幅と間隔が（Ｌに）等しいゲート部２２と微細な間隔Ｌを隔てて（ゲート部２２の）最小線幅Ｌに比べて大きい線幅（即ち、３Ｌ）が並んだコンタクト部２４を同時に解像することを目的としている。本発明に好適な線幅Ｌは、数式１に示すk_1と光源の波長λと投影光学系のＮＡに依存する。例えば、波長２４８ｎｍのＫｒＦエキシマレーザーとＮＡ＝０．６の投影光学系を使用した場合、数式１から理論解像Ｒはk_1＝０．２５として１０３ｎｍとなり、ＮＡ＝０．８５であればＲ＝７３ｎｍとなり、これがＬとなる。付近までまた、波長１９３ｎｍのＡｒＦエキシマレーザーを使用してＮＡ＝０．８５であれば、Ｒ＝５７ｎｍとなり、これがＬとなる。なお、k_1は０．２５から約０．５（あるいはそれ以上）まで変化することができる。

【００５９】まず２つのゲート部２２を解像するために、同一ピッチを持つ微細線と微細間隔の周期的なダミーのパターンを２つのゲート部２２の両側に複数形成して周期的な構造を有するパターンを形成する。ダミーのパターンを付加して周期的な構造を形成することによって、解像性能の向上と線幅の精度良い制御が可能になる。この周期的なパターンは位相シフトマスクによって極限の解像力を得る。

【００６０】所望のパターン２０にダミーパターン３０を重ねることによって形成されたマスクパターン４０を有する位相シフトマスク５０の一例を図７に示す。同図に示すように、所望のパターン２０は、上述したように、一対のパターン部２１から構成される。ダミーパターン３０は、互いに平行な光透過部３２及び３４と遮光

部３６とを有し、光透過部と遮光部３６とは交互に整列する。光透過部３２及び３４と遮光部３６のそれぞれのＹ方向の幅は図６に示すＬ（本実施形態では０．１２μｍ）に等しい。光透過部３２と３４とは位相が０度及び１８０度に設定されて互いに１８０度反転しており、光透過部３２及び３４はＹ方向に交互に整列している。光透過部３２及び３４は透過率１（又は１００％）を有し、遮光部３６は透過率０を有する。遮光部３６は、例えば、クロム等により構成される。

【００６１】各パターン部２１のゲート部２２はダミーパターン３０の遮光部３６に重ね合わされている。２つのゲート部２２の間は所望のパターン２０の一部として把握されてもよいが、ここでは位相が１８０度に設定された光透過部３４として把握されている。また、各コンタクト部２４は、遮光部２４ａ及び２４ｃと、光透過部３２が重ねられた光透過部２４ｂとを有する。即ち、領域２４ｂは、図６と図７を参照すると、ダミーパターン３０を重ねられたことによって遮光部から光透過部に変化されていることが理解される。光透過部２４ｂの透過率は１（１００％）であり、遮光部２２、２４ａ及び２４ｃの透過率は０である。

【００６２】次に、（例えば、図３（Ａ）に示す開口絞り１５０Ａがもたらす照明光のような）光軸近傍に強度分布のピークを有する照明光を使用する照明と、（例えば、図３（Ｂ）に示す開口絞り１５０Ｂがもたらす照明光のような）軸外に強度分布のピークを有する照明光との和として生じる多重照明光（例えば、図３（Ｄ）に示す開口絞り１５０Ｄがもたらす照明光）利用して位相シフトマスク５０を露光した。このとき、後述するプレート４００上に生じる光強度分布の結果を図８に示す。

【００６３】図８（Ａ）は、図６に示すＡ断面を含む断面に関するプレート４００上の光強度分布である。図８（Ｂ）は、図６に示すＡ断面を含む断面に関するプレート４００上の光強度分布である。プレート４００上の強度分布はプレート４００のレジストの露光量分布と解釈できる。図８（Ａ）を参照するに、Ａ断面に関して、光透過部２４ｂの光強度が高すぎてコンタクト部２４が正しくプレート４００に転写されないことが理解される。図８（Ｂ）を参照するに、Ｂ断面に関して、後述するプレート４００のレジストの閾値を色々振っても、ダミーパターン３０が残ってしまってゲート部２２が正しくプレート４００に転写されないことが理解される。

【００６４】そこで、所望のパターン２０のゲート部２２（即ち、微細部分）を少し太らせることにより、ダミーパターン３０との露光量に差をつけて所望のパターン２０を強調し、所望のパターン２０がプレート４００に解像されるようにした。このときの位相シフトマスクが本発明の一側面としてのマスク２００である。以下、図９を参照して、位相シフトマスク２００を説明する。ここで、図９（Ａ）は、位相シフトマスク２００の概略平面図である。図９（Ｂ）は位相シフトマスク２００の部分拡大図である。図９（Ｃ）は図９（Ｂ）に示す位相シフトマスク２００の変形例である。同図に示すように、位相シフトマスク２００は、一部が太くされた所望のパターン２１０と、ダミーパターン２４０とから構成されるマスクパターン２６０を有する。

【００６５】所望のパターン２１０はゲートパターン２０に類似するが一部が太くされている点で相違する。所望のパターン２１０は、一対のパターン部２１２ａ及び２１２ｂ（特に断らない限り、参照番号２１２は両者を総括する。）から構成され、各パターン部２１２は、Ｄ断面を通る微細なゲート部２２０と、Ｃ断面を通る２つのコンタクト部２３０とから構成される。

【００６６】両ゲート部２２０は、それぞれ微細な線幅（Ｌよりも多少大きい線幅Ｌ１）を有する長方形であり、微細な間隔（Ｌよりも多少小さい間隔）で平行に整列している。本実施形態ではＬは０．１２μｍである。

【００６７】一方、コンタクト部２３０は、それぞれ例示的に線幅３Ｌよりも多少大きな線幅を有する長方形であり、二対のコンタクト部が微細な間隔（Ｌよりも多少小さい間隔）を介して平行に整列している。各パターン部２１２には２つのコンタクト部２３０がゲート部２２０の両端に設けられている。本発明は、このように微細な線幅と間隔がほぼ等しいゲート部２２０と微細な間隔（Ｌよりも多少小さい間隔）を隔てて（ゲート部２２０の）最小線幅Ｌに比べて大きい線幅（即ち、３Ｌよりも多少大きな線幅）が並んだコンタクト部２３０を同時に解像することを目的としている。

【００６８】ダミーパターン２４０は、２つのゲート部２２０を解像するために、２つのゲート部２２０の両側に複数形成され、同一ピッチＬを有する微細線と微細間隔の周期的な構造を有する。ダミーパターン２４０を付加して周期的な構造を形成することによって、解像性能の向上と線幅の精度良い制御が可能になる。この周期的なパターンは位相シフトマスクによって極限の解像力を得る。

【００６９】ダミーパターン２４０は、互いに平行な光透過部２４２及び２４４と遮光部２４６とを有し、光透過部と遮光部２４６とは交互に整列する。光透過部２４２及び２４４と遮光部２４６のそれぞれのＹ方向の幅はＬ（本実施形態では０．１２μｍ）に等しい。光透過部２４２と２４４とは位相が０度及び１８０度に設定されて互いに１８０度反転しており、光透過部２４２及び２４４はＹ方向に交互に整列している。遮光部２４６は、例えば、クロム等により構成される。光透過部２４２及び２４４の透過率は１（１００％）であり、遮光部２４６の透過率は０である。

【００７０】各パターン部２１２のゲート部２２０はダミーパターン２４０の遮光部２４６に重ね合わされている。２つのゲート部２２０の間は所望のパターン２１０

の一部として把握されてもよいが、ここでは位相が180度に設定された光透過部244として把握されている。また、各コンタクト部230は、遮光部232及び236と、光透過部242が重ねられた光透過部234とを有する。即ち、領域234はダミーパターン240が重ねられたことによって遮光部から光透過部に変化されている。光透過部234の透過率は1（100%）であり、遮光部220、232及び236の透過率は0である。

【0071】図9（A）に示すように、ゲート部220と、コンタクト部230の遮光部232及び236の線幅は、本来、それぞれLであったものがL1（>L）に大きくされている。また、図9（B）を参照するに、遮光部232及び236のそれぞれが、遮光部246の中心線U1及びU2に関して、等しくL2だけ外側に太くされている。この結果、L1はL+2×L2であることが理解される。また、領域234の線幅はL−2×L2であることが理解される。本実施形態と異なり、遮光部232及び236は、それぞれ中心線U1及びU2に関して左右異なる幅で太くされてもよいし、例えば、図9（C）に示すように左右の一方で太くされてもよい。また、遮光部232が太くされる線幅と遮光部236が太くされる線幅は異なってもよい。遮光部232及び236をこのように太くする理由は所望のパターン210をダミーパターン240から露光量に関して差を設けるためである。線幅Lに対して太くされるべき線幅L1の比は、例えば、数十%程度（例えば、約17%）である。

【0072】本実施形態では、ゲート部220の線幅は遮光部232と同様であるので（即ち、本実施例ではL+2×L2）、ここでは説明は省略する。選択的に、ゲート部220の線幅を遮光部232と異なるものにしてもよいし、中央線U1に関してゲート部220は左右非対称に太くされてもよい。

【0073】次に、（例えば、図3（A）に示す照明光の開口絞り150Aがもたらす照明光のような）光軸近傍に強度分布のピークを有する照明光を使用する照明と、（例えば、図3（B）に示す開口絞り150Bがもたらす照明光のような）軸外に強度分布のピークを有する照明光との和として生じる多重照明光（例えば、図3（D）に示す開口絞り150Dがもたらす照明光）利用して位相シフトマスク200を露光した。このとき、後述するプレート400上に生じる光強度分布の結果を図10に示す。

【0074】図10（A）は、図9（A）に示すC断面を含む断面に関するプレート400上の光強度分布である。図10（B）は、図9（A）に示すD断面を含む断面に関するプレート400上の光強度分布である。プレート400上の強度分布はプレート400のレジストの露光量分布と解釈できる。図10（A）を図8（A）と比較すると、C断面に関して、光透過部234の光強度が光透過部24bよりも減少していることが理解される。これは光透過部234の線幅がLよりも小さくなった（L−2×L2）ためである。このため、レジストの閾値を適当に振ると、コンタクト部230がプレート400に転写できることが理解される。図10（B）を図8（B）と比較すると、D断面に関して、ゲート部220の間の光透過部244の光強度がゲート部22の間の光透過部34よりも減少していることが理解される。これはゲート部220の間の光透過部244の線幅がLよりも小さくなった（L−2×L2）ためである。このため、レジストの閾値を適当に振ると、ゲート部220がプレート400に転写できることが理解される。以上から、レジストの閾値を適当に振ると所望のパターン210が正しくプレート400に転写できることが理解される。

【0075】次に、図12を参照して、マスク200の変形例としてのマスク200Aを説明する。ここで、図12は、マスク200Aの概略平面図である。マスク200Aは、同図に示すように、所望のパターン210と、ダミーパターン240Aとから構成されるマスクパターン260Aを有する。所望のパターン210は、図9と同様であるため、説明は省略する。

【0076】ダミーパターン240Aは光透過部242A及び244Aから構成され、両者は位相が0度と180度に設定されて180度反転している。光透過部242A及び244Aは、Y方向にそれぞれ幅2Lを有し、Y方向に交互に平行に整列している。このように、本実施形態のダミーパターン240Aは、図9に示すダミーパターン240とは異なり、遮光部を有しない。従って、クロムなどから構成される遮光部を有するのは所望のパターン210のみとなる。このようなクロムレス構成により、所望のパターン210とダミーパターン240Aとの露光量に差をつけることが可能である。

【0077】即ち、光透過部234の幅が光透過部242A及び244Aの幅よりも小さいので、図8（A）の中央部の露光量は図10（A）の中央部に示す露光量と同じように減少することが理解されるであろう。同様に、二対の遮光部232によって挟まれた光透過部244A（及び一対のゲート部220によって挟まれた光透過部244A）の幅が光透過部242A及び244Aの幅よりも小さいので、図8（B）の中央部の露光量は図10（B）の中央部に示す露光量と同じように減少することが理解されるであろう。この結果、所望のパターン210をコントラスト良くプレート400に転写することができる。

【0078】なお、所望のパターン210において位相が反転する境界部の線幅を適宜設定し、所望のパターン210とダミーパターン240との露光量を最適に制御しても同様の効果が得られることが理解されるであろう。

【0079】次に、図14を参照して、マスク200の変形例としてのマスク200Bを説明する。ここで、図14は、マスク200Bの概略平面図である。マスク200Bは、同図に示すように、所望のパターン210Aと、ダミーパターン240Aとから構成されるマスクパターン260Bを有する。ダミーパターン240Aは、図12と同様であるため、説明は省略する。

【0080】図14に示すように、所望のパターン210は、一対のパターン部214a及び214b(特に断らない限り、参照番号「214」はこれらを総括するものとする。)からなり、各パターン部214は、ゲート部220と一対のコンタクト部230Aから構成される。各コンタクト部230Aは、光透過部234Aと遮光部232及び236とを有する。ゲート部220及び遮光部232及び236は図9を参照して上述したものと同様であるのでここでは説明は省略する。

【0081】光透過部234Aは透過率が1(100%)ではなく0.7(70%)に設定されている。これにより、所望のパターン210Aとダミーパターン240Aとの露光量に差をつけることが可能である。即ち、光透過部234Aの幅が光透過部242A及び244Aの幅よりも小さく透過率も低いので、図8(A)の中央部の露光量は図10(A)の中央部に示す露光量と同じように減少することが理解されるであろう。

【0082】なお、光透過部234Aを使用すれば、ダミーパターン240Aはダミーパターン240であってもよいことが理解されるであろう。また、二対の遮光部232によって挟まれた光透過部244A(及び一対のゲート部220によって挟まれた光透過部244A)の透過率を同様に0.7(70%)に設定してよいことはもちろんである。

【0083】このように、所望のパターンの一部(パターン部212の間を含む)の光透過率を制御することにより、所望のパターン210をコントラスト良くプレート400に転写することができる。

【0084】投影光学系300は、マスク200に形成されたマスクパターン260を経た回折光をプレート400上に結像するための開口絞り320を有する。投影光学系300は、複数のレンズ素子のみからなる光学系、複数のレンズ素子と少なくとも一枚の凹面鏡とを有する光学系(カタディオプトリック光学系)、複数のレンズ素子と少なくとも一枚のキノフォームなどの回折光学素子とを有する光学系、全ミラー型の光学系等を使用することができる。色収差の補正が必要な場合には、互いに分散値(アッベ値)の異なるガラス材からなる複数のレンズ素子を使用したり、回折光学素子をレンズ素子と逆方向の分散が生じるように構成したりする。上述したように、投影光学系300の瞳面320に形成される有効光源の形状は図3乃至図5に示す形状と同様である。

【0085】プレート400は、本実施形態ではウェハであるが、液晶基板その他の被処理体を広く含む。プレート400にはフォトレジストが塗布されている。フォトレジスト塗布工程は、前処理と、密着性向上剤塗布処理と、フォトレジスト塗布処理と、プリベーク処理とを含む。前処理は洗浄、乾燥などを含む。密着性向上剤塗布処理は、フォトレジストと下地との密着性を高めるための表面改質(即ち、界面活性剤塗布による疎水性化)処理であり、HMDS(Hexamethyl-disilazane)などの有機膜をコート又は蒸気処理する。プリベークはベーキング(焼成)工程であるが現像後のそれよりもソフトであり、溶剤を除去する。

【0086】プレート400はウェハステージ450に支持される。ステージ450は、当業界で周知のいかなる構成をも適用することができるので、ここでは詳しい構造及び動作の説明は省略する。例えば、ステージ450はリニアモータを利用してXY方向にプレート400を移動する。マスク200とプレート400は、例えば、同期して走査され、図示しないマスクステージとウェハステージ450の位置は、例えば、レーザー干渉計などにより監視され、両者は一定の速度比率で駆動される。ステージ450は、例えば、ダンパを介して床等の上に支持されるステージ定盤上に設けられ、マスクステージ及び投影光学系300は、例えば、鏡筒定盤は床等に載置されたベースフレーム上にダンパ等を介して支持される図示しない鏡筒定盤上に設けられる。

【0087】結像位置調節装置500は、ステージ450に接続されてステージ450と共にプレート400を焦点深度の範囲内で図1に示すZ方向に移動させ、プレート400の結像位置を調節する。露光装置1は、必要があれば、Z方向において異なる位置に配置されたプレート400に対して露光を複数回行うことにより、焦点深度内における結像性能のばらつきをなくすこともできる。結像位置調節装置500は、Z方向に伸びる図示しないラックと、ステージ450に接続されてラック上を移動可能な図示しないピニオンと、ピニオンを回転させる手段など、当業界で周知のいかなる技術をも適用することができるので、ここでは詳しい説明は省略する。

【0088】露光において、レーザー112から発せられた光束は、ビーム成形系114によりそのビーム形状が所望のものに成形された後で、照明光学系120に入射する。集光光学系130は、それを通過した光束をオプティカルインテグレータ140に効率よく導入する。その際、露光量調節部132が照明光の露光量を調節する。オプティカルインテグレータ140は照明光を均一化し、開口絞り150は、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とが合成された照明光を形成する。かかる照明光はコンデンサーレンズ160を介して位相シフトマスク200を最適な照明条件で照明する。

【0089】マスク２００には、一部の線幅が太くされた所望のパターン２１０と、パターン２１０に重ねられたダミーパターン２４０とから構成されたマスクパターン２６０が形成されている。ゲート部２２０は、ダミーパターン２４０の遮光部（暗線部）２３６に重ねられてＬ＆Ｓパターンをダミーパターン２４０と共に形成し、位相シフトマスクにより解像性能が高められている。また、ゲート部２２０は、ダミーパターン２４０よりも太くされてその間の光透過部はダミーパターン２４０よりも露光量が減少している。コンタクト部２３０は、ダミーパターン２４０に重ねられて一部（即ち、領域２３４）が光透過部に変化され、一部（即ち、遮光部２３２及び２３６）がダミーパターン２４０の線幅よりも太くされ、その結果、光透過部２３４がダミーパターン２４０よりも露光量が減少している。

【0090】マスク２００を通過した光束は投影光学系３００の結像作用によって、プレート４００上に所定倍率で縮小投影される。ステップアンドスキャン方式の露光装置１であれば、光源部１１０と投影光学系３００は固定して、マスク２００とプレート４００の同期走査してショット全体を露光する。更に、プレート４００のステージ４５０をステップして、次のショットに移り、プレート４００上に多数のショットを露光転写する。なお、露光装置１がステップアンドリピート方式であれば、マスク２００とプレート４００を静止させた状態で露光を行う。

【0091】光軸近傍に強度分布のピークを有する照明光は位相シフトマスク２００を照明して微細な周期パターンの強度分布をプレート４００上に形成する。軸外に強度分布のピークを有する照明光はマスク２００を照明して粗く露光する。位相シフトマスク２００のゲート部２２０の間の光透過部２４４と２３４はパターン幅が狭いために露光量が減少し、所望のパターン２１０をダミーパターン２４０から分離するのに寄与する。この結果、プレート４００のレジストの閾値を適当に選択することによって所望のコンタクトホール２１０のパターンをプレート４００上に形成することができる。これにより、露光装置１はレジストへのパターン転写を高精度に行って高品位なデバイス（半導体素子、ＬＣＤ素子、撮像素子（ＣＣＤなど）、薄膜磁気ヘッドなど）を提供することができる。

【0092】次に、図１７及び図１８を参照して、上述の露光装置１を利用したデバイスの製造方法の実施例を説明する。図１７は、デバイス（ＩＣやＬＳＩなどの半導体チップ、ＬＣＤ、ＣＣＤ等）の製造を説明するためのフローチャートである。ここでは、半導体チップの製造を例に説明する。ステップ１（回路設計）ではデバイスの回路設計を行う。ステップ２（マスク製作）では、設計した回路パターンを形成したマスクを製作する。ステップ３（ウェハ製造）ではシリコンなどの材料を用いてウェハを製造する。ステップ４（ウェハプロセス）は前工程と呼ばれ、マスクとウェハを用いて本発明のリソグラフィ技術によってウェハ上に実際の回路を形成する。ステップ５（組み立て）は後工程と呼ばれ、ステップ４によって作成されたウェハを用いて半導体チップ化する工程であり、アッセンブリ工程（ダイシング、ボンディング）、パッケージング工程（チップ封入）等の工程を含む。ステップ６（検査）では、ステップ５で作成された半導体デバイスの動作確認テスト、耐久性テストなどの検査を行う。こうした工程を経て半導体デバイスが完成し、これが出荷（ステップ７）される。

【0093】図１８は、ステップ４のウェハプロセスの詳細なフローチャートである。ステップ１１（酸化）ではウェハの表面を酸化させる。ステップ１２（ＣＶＤ）では、ウェハの表面に絶縁膜を形成する。ステップ１３（電極形成）では、ウェハ上に電極を蒸着などによって形成する。ステップ１４（イオン打ち込み）ではウェハにイオンを打ち込む。ステップ１５（レジスト処理）ではウェハに感光剤を塗布する。ステップ１６（露光）では、露光装置１によってマスクの回路パターンをウェハに露光する。ステップ１７（現像）では、露光したウェハを現像する。ステップ１８（エッチング）では、現像したレジスト像以外の部分を削り取る。ステップ１９（レジスト剥離）では、エッチングが済んで不要となったレジストを取り除く。これらのステップを繰り返し行うことによってウェハ上に多重に回路パターンが形成される。

【0094】

【実施例１】実施例１では図９に示す位相シフトマスク２００と、レーザー１１２にＫｒＦエキシマレーザー（波長２４８ｎｍ）と、図４（Ａ）に示す開口絞り１５０Ｇと、ＮＡ０．６０の投影光学系３００とを露光装置１に使用した。位相シフトマスク２００において、図９（Ｂ）に示すＬはウェハ（プレート４００）面上換算で１２０ｎｍでＬ１は１４０ｎｍ（即ち、Ｌ２＝１０ｎｍ）とした。ダミーパターン２４０は１２０ｎｍのＬ＆Ｓパターンとした。

【0095】かかる露光装置１を、（図３（Ａ）に示す開口絞り１５０Ａが与える照明光のような）光軸近傍に強度分布のピークを有する照明光、（図３（Ｂ）に示す開口絞り１５０Ｂが与える照明光のような）軸外に強度分布のピークを有する四重極照明光（各円形開口の中心位置のσをｘ、ｙ方向それぞれ０．６の位置に、各円形開口の大きさのσを０．３とする。）、及び、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光が合成された、（図３（Ｄ）に示す開口絞り１５０Ｄが与える照明光のような）五重極照明光（中心部のσは０．３、他は四重極照明光と同じ）でそれぞれ露光した。また、露光量調整部１３２によって五重極照明光の光軸近傍に強度分布のピークを有する

照明光と軸外に強度分布のピークを有する照明光との強度比は０．９対１に設定した。

【００９６】これらの露光の結果を図１１に示す。図１１（Ａ）を参照するに、光軸近傍に強度分布のピークを有する照明光を使用した場合には微小周期構造のみが露光されている。図１１（Ｂ）を参照するに、四重極照明光を使用した場合には、大きなパターン部のみが露光されて微細周期パターンは解像されていない。図１１（Ｃ）を参照するに、これらを多重した五重極照明光を使用した場合には所望のゲートパターン２１０全体が解像されている。図１１（Ａ）乃至（Ｃ）は、解像位置調節装置５００によって横方向に焦点深度内の焦点からの距離を－０．４μｍ～＋０．４μｍまで振った場合の露光パターン特性である。これらは、図１０を参照して説明したものと同様の結果となった。

【００９７】五重極照明光を使用した場合、図１１（Ｃ）に示すように、微細なパターンの解像性が非常によい０．１２μｍパターンが形成された。数式１における線幅Ｒを（λ／ＮＡ）で割ってk_1で規格化すると、k_1＝０．２９のパターンが解像されたことになる。

【００９８】

【実施例２】実施例２では図１２に示す位相シフトマスク２００Ａを使用し、開口絞り１５０には、開口絞り１５０Ｄを使用する等して、光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とを両方使用した。その他の露光条件は実施例１と同様にした。このときの結果を図１３に示す。図１１（Ｃ）と同様の結果が得られていることが理解されるであろう。

【００９９】

【実施例３】実施例３では図１４に示す位相シフトマスク２００Ｂを使用した。その他の露光条件は実施例２と同様にした。このときの結果を図１５に示す。図１１（Ｃ）と同様の結果が得られていることが理解されるであろう。

【０１００】本発明によれば、最小線幅が０．１５μｍ以下の微細な複雑なパターンが、マスク２００を交換せずにプレート４００面上に焦点深度内の異なる位置で結像特性良く転写することができた。本実施例では、ＫｒＦエキシマレーザー、ＮＡ＝０．６の露光装置１で最小線幅と最小間隔がともに０．１２μｍのパターンが解像された。なお、解像線幅をk_1で規格化するとk_1＝０．２９、ピッチ０．２９×２＝０．５８である。従って、微細な線幅とそれより大きな線幅からなる複雑なパターンの解像がマスクを交換することなく露光することが可能になり、ウェハ面上に所定のパターンの形成が可能になった。

【０１０１】以上、本発明の好ましい実施例を説明したが、本発明はこれらに限定されずにその趣旨の範囲内で様々な変形や変更が可能である。

【０１０２】

【発明の効果】本発明のマスク、露光方法及び装置によれば、微細な（例えば、０．１５μｍ以下の）線幅を持ち、Ｌ＆Ｓパターンから孤立及び複雑なパターンまでが混在するマスクパターンを、マスクを交換せずに、高解像度に露光することができる。また、かかる露光方法及び装置を使用したデバイス製造方法は高品位なデバイスを製造することができる。

【図面の簡単な説明】

【図１】　本発明の露光装置の概略ブロック図である。

【図２】　図１に示す露光装置の露光量調整部が調整可能な照明光の一例を示す光強度分布である。

【図３】　図１に示す露光装置の開口絞りの例示的形状の概略平面図である。

【図４】　図１に示す開口絞りの別の例示的形状の概略平面図である。

【図５】　図１に示す開口絞りの更に別の例示的形状の概略平面図である。

【図６】　所望のパターンの概略平面図である。

【図７】　図６に示すパターンにダミーのパターンを重ねることによって形成された位相シフトマスクの一例である。

【図８】　光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とを利用して図７に示す位相シフトマスクを照明した場合の図１に示すプレートに生じる光強度分布である。

【図９】　本発明の位相シフトマスクの概略平面図である。

【図１０】　光軸近傍に強度分布のピークを有する照明光と軸外に強度分布のピークを有する照明光とを利用して図９に示すマスクを照明した場合に図１に示す露光装置のプレートに現れる光強度分布である。

【図１１】　実施例１の露光結果として、図９に示す位相シフトマスクを異なる照明条件で照明した場合のプレートに転写されたパターンである。

【図１２】　図９に示す位相シフトマスクの変形例の概略平面図である。

【図１３】　実施例２の露光結果として、図１２に示す位相シフトマスクを異なる照明条件で照明した場合のプレートに転写されたパターンである。

【図１４】　図９に示す位相シフトマスクの別の変形例の概略平面図である。

【図１５】　実施例３の露光結果として、図１４に示す位相シフトマスクを異なる照明条件で照明した場合のプレートに転写されたパターンである。

【図１６】　図１に示す露光装置のオプティカルインテグレータの変形例の拡大斜視図である。

【図１７】　本発明の露光装置を有するデバイス製造方法を説明するためのフローチャートである。

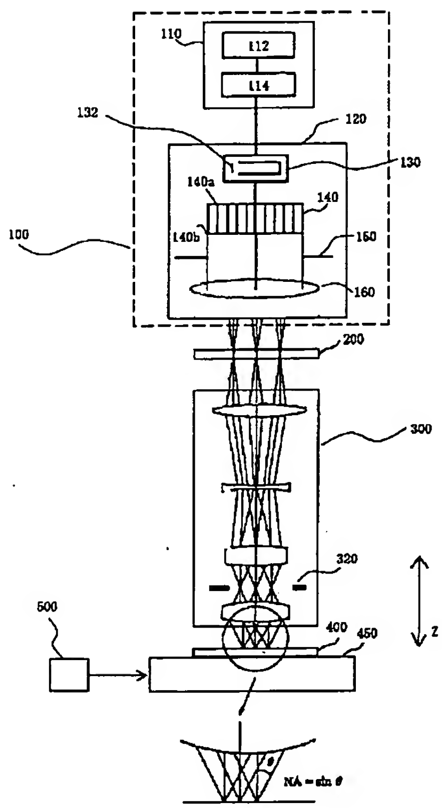
【図１８】　図１７に示すステップ４の詳細なフローチ

ャートである。

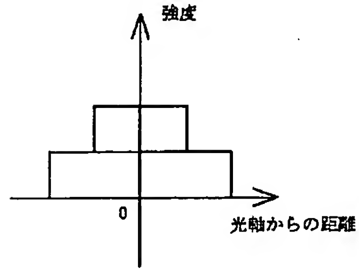
【符号の説明】

1	露光装置
100	照明装置
120	照明光学系
132	露光量調整部
150	開口絞り
200	マスク
210	所望のパターン
240	ダミーのパターン
260	マスクパターン
300	投影光学系
320	瞳
400	プレート

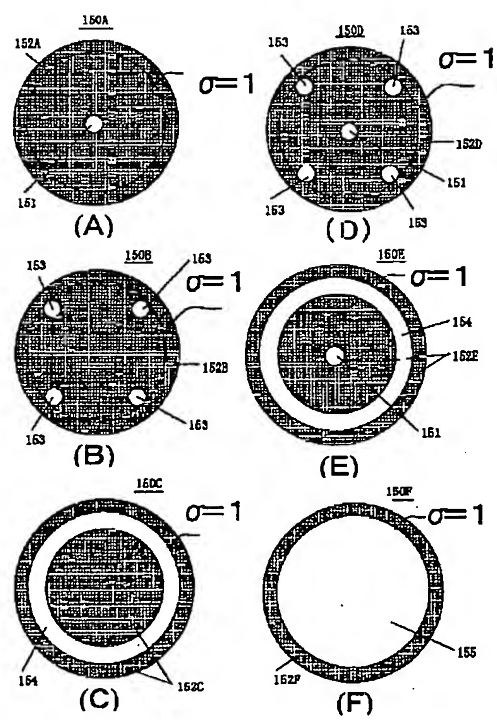
【図1】



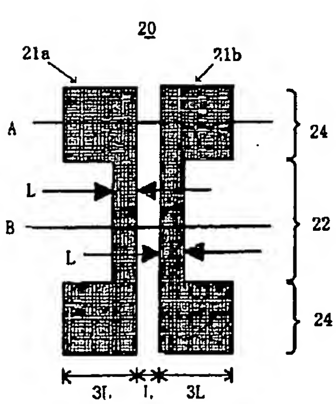
【図2】



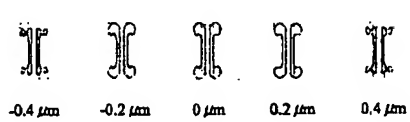
【図3】



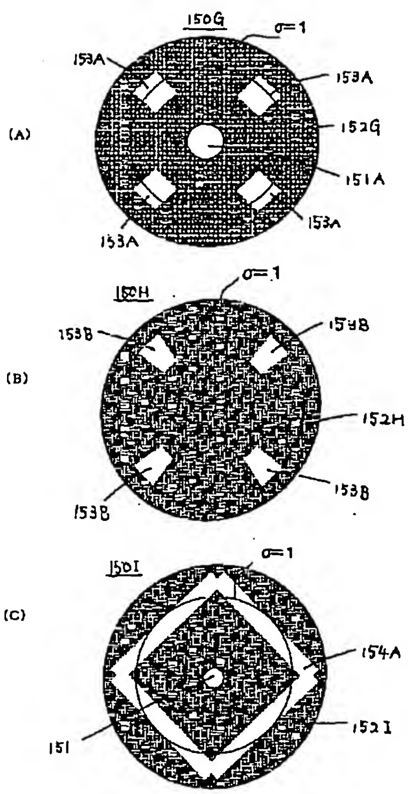
【図6】



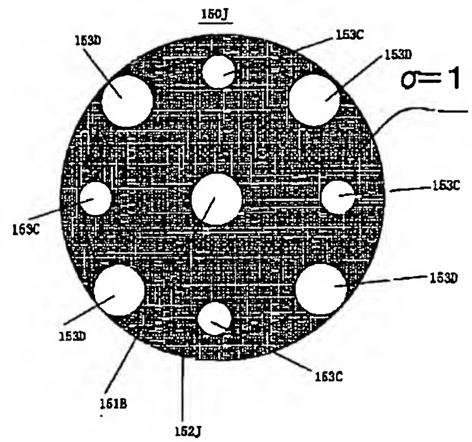
【図13】



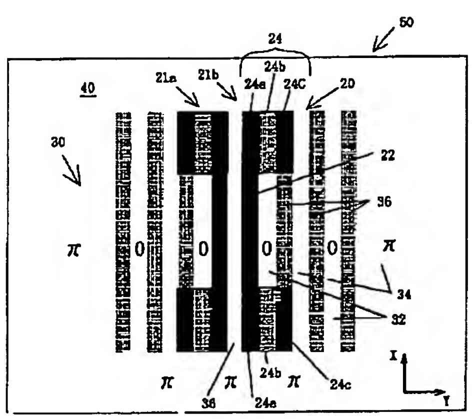
【図4】



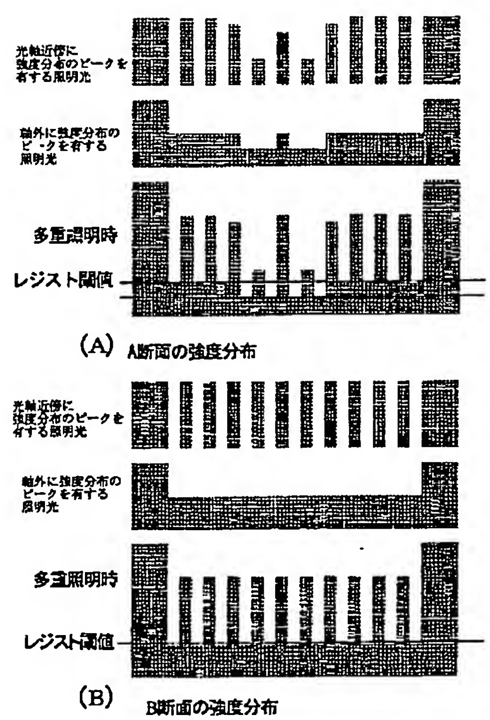
【図5】



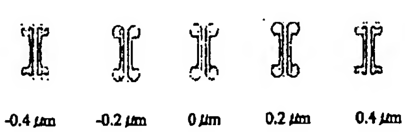
【図7】



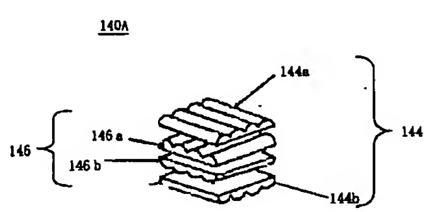
【図8】



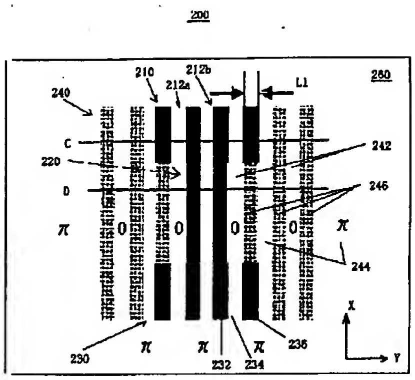
【図15】



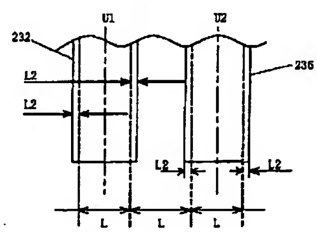
【図16】



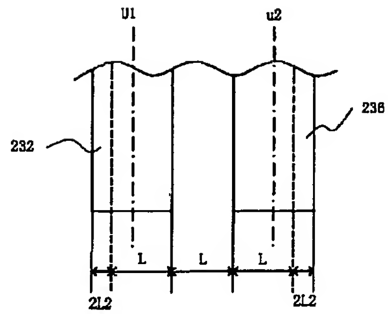
【図9】



(A)

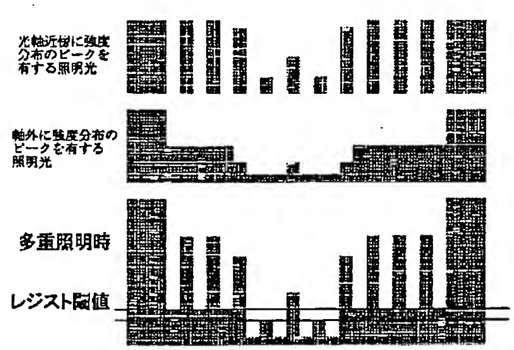


(B)

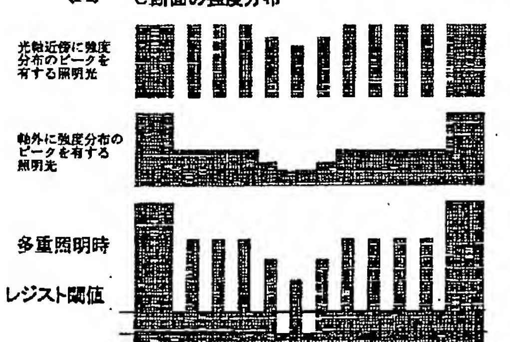


(C)

【図10】

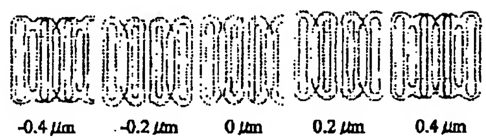


(A) C断面の強度分布

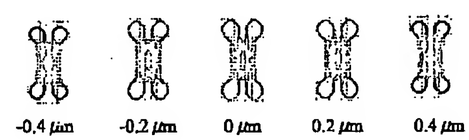


(B) D断面の強度分布

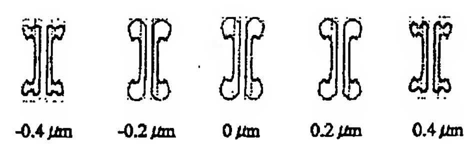
【図11】



(A)

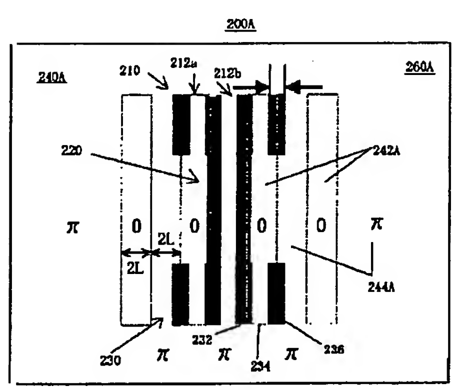


(B)

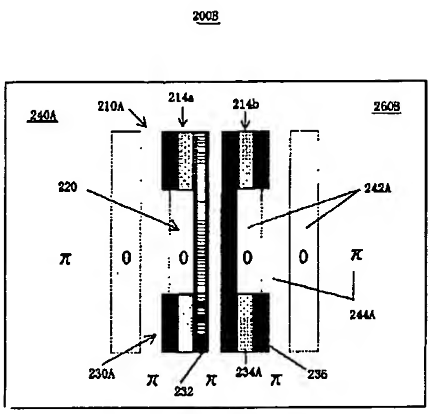


(C)

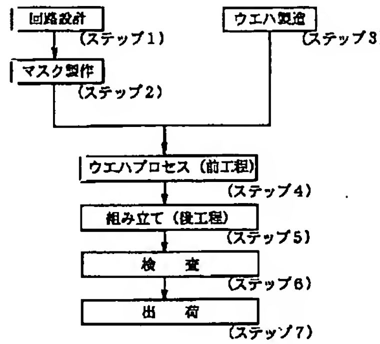
【図12】



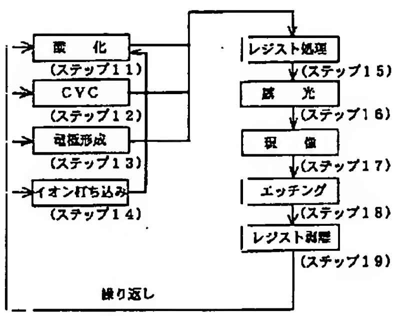
【図14】



【図17】



【図18】



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(51)Int.Cl.⁷	識別記号	F I		(参考)
		H01L　21/30	502P	
			514C	
			515D	